POWER

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Increasing Efficiency at No Expense

JUDICIOUS use of commendation for work well done is a powerful aid in maintaining the spirit and good will of the members of an organization as well as in increasing the efficiency and the output; yet there are literally thousands of men in positions of authority who are utterly blind to the value of this instrument in their hands, if we may judge by their failure to use it.

The man who is absolutely callous and unresponsive to a word of praise for the performance of a good piece of work has yet to be discovered. Natural modesty may prevent an individual from openly showing that he is pleased, but there is no way by which he can disguise or ignore the warm glow that thrills through him when he hears words of approval. Human nature loves lip-homage.

No class of worker is immune from the effects of a complimentary remark. The superintendent may wear a silk undershirt and the fireman may cover his torso with red flannel, but beneath the skin they are both human and therefore equally susceptible to the magic of an appreciative look or word. If the board of directors, at the annual meeting, passes a resolution congratulating the superintendent on the showing he has made during the year, he carries that congratulatory letter around in his pocket and shows it to his intimate friends until it becomes worn at the creases and frayed at the edges; moreover, he goes at the work of the new year with an increased determination to improve on his already good record.

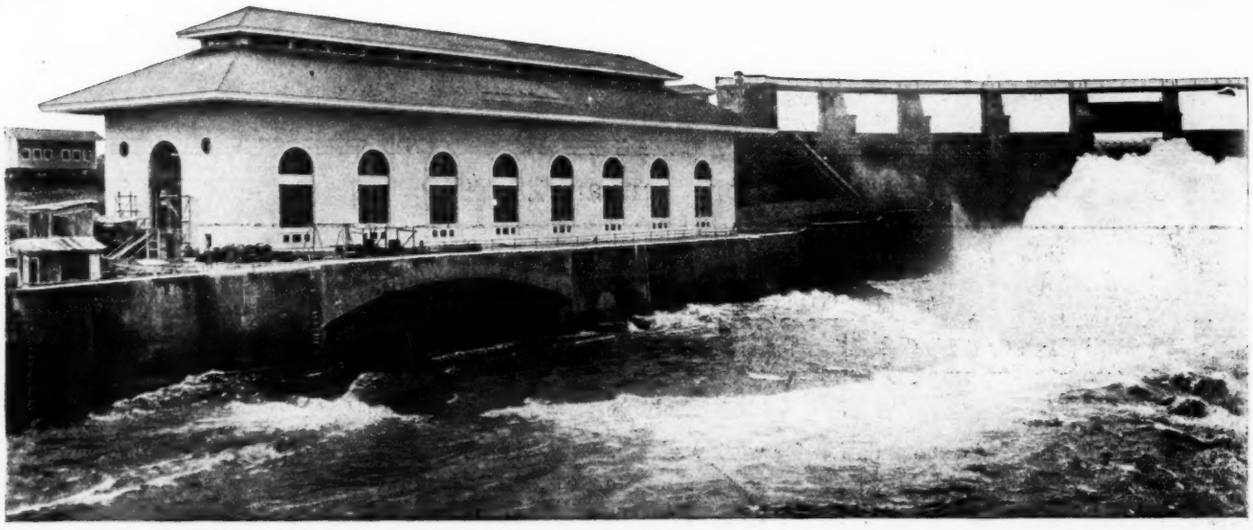
Similarly, if that same superintendent pauses on his way through the plant to tell the fireman that he has been right on the job and doing fine work, according to the figures on the daily report sheets, that fireman involuntarily suffers an increase of chest expansion measurable in inches and the chances are that he goes home and tells his wife that his boss has at last discovered his abilities.

Recognition—that is the whole matter in a nutshell. To a greater or less degree we all like to attract attention to ourselves or to our achievements. One of the most discouraging and depressing things in the world is indifference. But when to indifference is added routine work of an unattractive and oftentimes laborious nature, we have a plausible explanation of the lack of interest and the general low efficiency in many branches of industry.

There are employers and chiefs who never praise the meritorious efforts of subordinates. Just why they should be so chary of approval is a mystery. If a few well-chosen words of tribute required the spending of money or involved a lowering of prestige or influence, withholding them could be understood; but they cost nothing and their influence is beyond all calculation. To many a man, weary with repetition of the same motions and the same round of duties, they come like a refreshing breath of air and they act as a pleasing stimulus to better performance.

There may be excellent reasons why it is impossible to increase the pay of an employee who has accomplished praiseworthy results, but there is no excuse for failure to show recognition of his services when they are unusual in quality or value. More than that, the time to speak the "Well done!" is now. If a man deserves praise for what he has produced, let him know it while he can hear the sound of your voice. Eulogies do not penetrate very far within coffin walls.

By Rufus T. Strohm



Pumping Plant and Electrical Equipment at Balboa Shops, Canal Zone

By R. D. GATEWOOD*

THE pumping plant for the 1000-ft. drydock at Balboa, Canal Zone, has now been in operation for over two years and has proved itself to be eminently well-suited for the purpose, practically no material changes having been found necessary in the original plans for design and installation. The plant consists of four main pumps and two drainage pumps and one bilge or seepage pump located in a well near the entrance of the dry dock. These are installed in the building shown in Fig. 1, which also houses both the electric and steam air compressors.

The main pumps and drainage pumps, shown in Fig. 2, draw water from a suction chamber below the level of the dock floor, the latter through a separate duct below the level of the floor of the suction chamber. The bilge pump draws water from the pump well itself. All these pumps are operated on 2200-volt three-phase 25-cycle current. The main pumps have a capacity of 11,000 cu.ft. of salt water per minute against a head of 48 ft. This head exists when the pump is drawing from the bottom of the dock, which is at minus 39, and discharging against average high tide, or plus 8.5. Conditions may arise, however, when the pumps will be required to discharge against a tidal elevation of plus 13.

The drainage pumps are supplied for unwatering the suction chamber of the main pumps and for removing leakage, waste from ships in the dock, etc. These pumps are capable of discharging 1200 cu.ft. of water per min. against a head of 43.5 ft. and are equipped with both hand and automatic control, the latter being arranged so that whenever the water rises to a depth of 10 ft. in the suction chamber, the pumps will automatically start and operate until the chamber is empty. The bilge pump is required to empty the lowest part of the pump well at any stage of the tide and has a capacity of 25 cu.ft. of water per minute. This pump also is fitted with hand and automatic starting and stopping equipment.

The main pumps are vertical units driven by 1000-hp. motors. The discharge opening as well as the suction is 54 in. in diameter. The drainage pumps also are vertical units driven by 200-hp. motors, with discharge and suction openings 20 in. in diameter. Each of the foregoing units consists of a vertical-shaft, single bottom suction, single-impeller volute centrifugal pump direct-connected to the vertical motor shaft. The bilge pump is a 3-in. centrifugal pump driven by a 25-hp. motor.

The compressed air for use throughout the Balboa shops is supplied by two electrically operated Ingersoll-Rand compressors, one 40 x 25½ x 30 in. with a capacity of 5000 cu.ft. of free air per minute, and the other 28 x 17½ x 21 in. with a capacity of 2252 cu.ft. of free air per minute, delivered at a pressure of 105 lb. These machines, shown in Fig. 3, are driven by direct-connected synchronous motors operating on 2200-volt three-phase 25-cycle current. The larger machine has a 1016-hp. motor and the smaller a 460-hp. motor. The compressors are equipped with the Rogler plate valve and therefore operate at considerably higher speeds than has been possible for machines of the same size heretofore. They make 136.3 r.p.m. and 185.5 r.p.m., respectively, for the large and small machine. Each machine is two-stage and is fitted with an unloader by means of which it can be operated at no load, or at one-quarter, one-half, three-quarters or full load. The unloader works automatically so that the motor takes only enough current to maintain the required pressure in the distributing lines. The motors are operated at 75 per cent. leading power factor for improving the factor in the transmission line.

The plant is located in the combined air-compressor and pump plant on the south side of the dry dock, and distributing lines are run around the head of the dock to the shop mains as well as along the wharves and to the coaling plant.

The electric power for the whole Canal Zone is generated in the hydro-electric station at the spillway for

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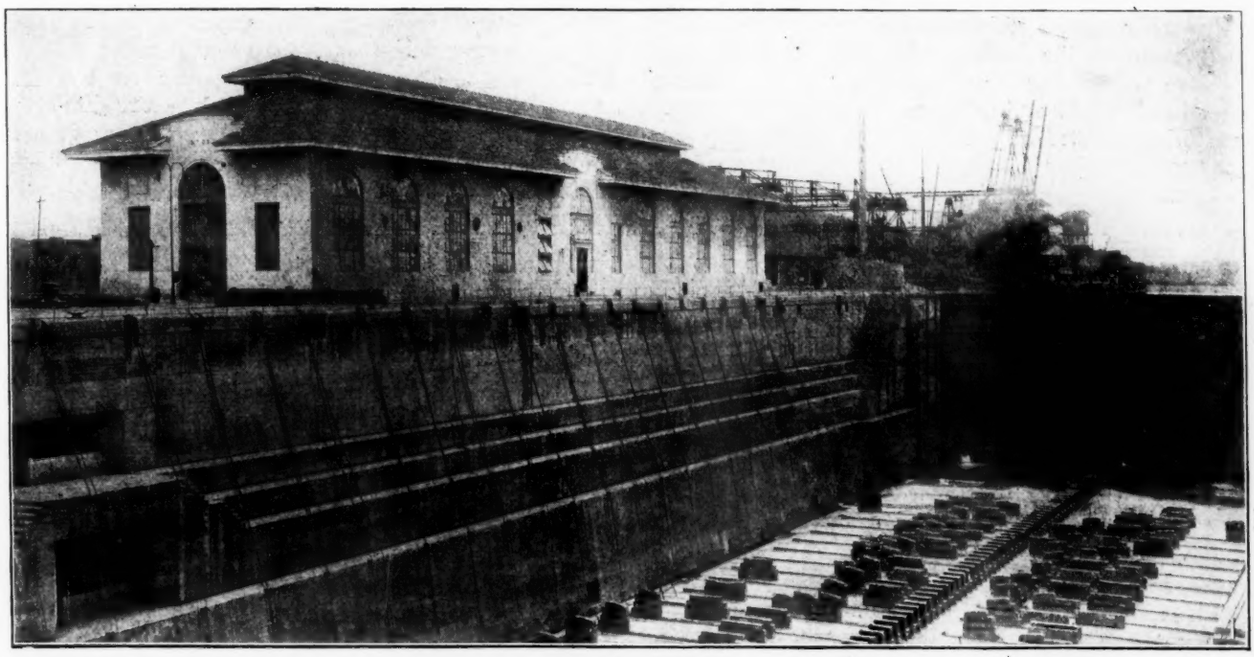
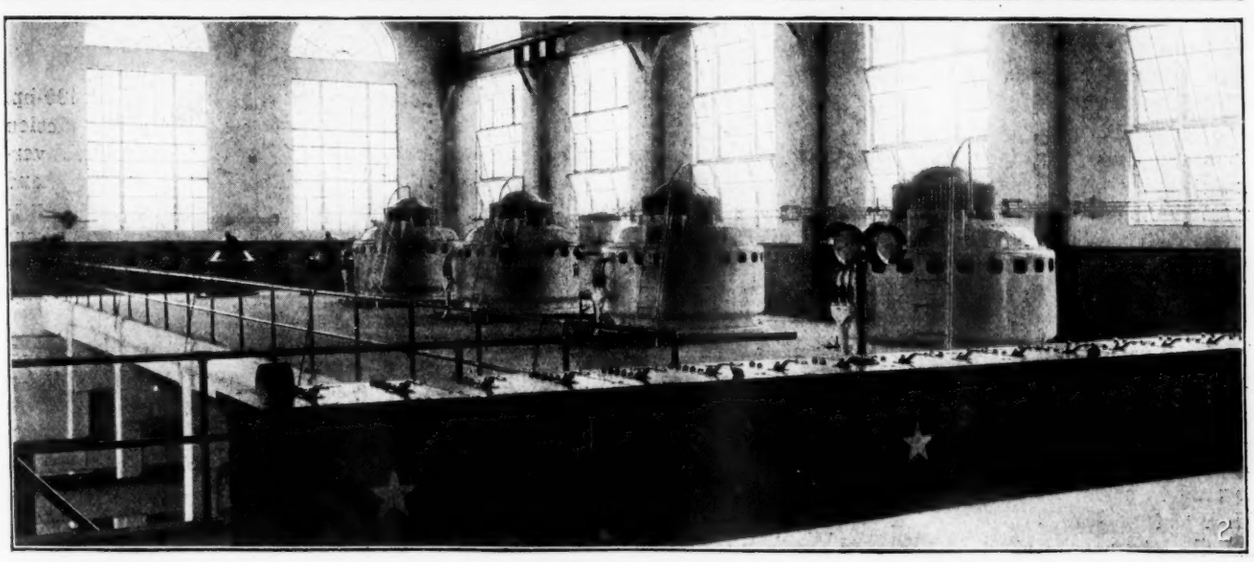
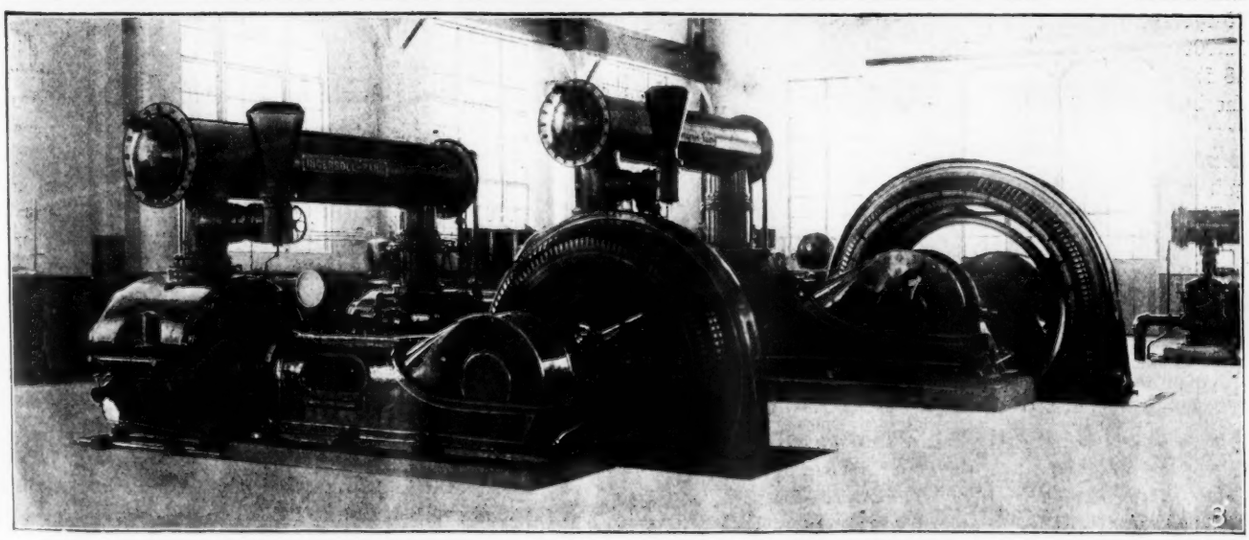






FIGS. 1 TO 3. EXTERIOR AND INTERIOR VIEWS OF DRY-DOCK PUMPING PLANT AT BALBOA SHOPS, PANAMA CANAL ZONE

Fig. 1—Building containing dry-dock pumps, air compressors and switchboard controlling power to shops. Fig. 2—Interior of building, showing pump motors and control board. Fig. 3—Electrically driven air compressors.

Gatun Lake and is transmitted across the Isthmus at 44,000 volts to the Balboa substation, which is alongside the Balboa shops. In this substation it is stepped down to 2200 volts and delivered at this voltage to small substations located at power centers in the shop area. The headpiece shows the hydro-electric station at Gatun, with one spillway gate open to allow excess water to escape from the lake.

The machinery in the shops is entirely electrically operated, except such machines as hammers, etc., which are not adapted to this type of drive. The current used is three-phase 25-cycle and is delivered to the shops at 2200 volts. The shop motors operate at 220 volts and transformer rooms are located near load centers in the various buildings. The main transformer rooms are placed in the machine and erecting shop, steel storage shed, planing mill and foundry building. The machine and erecting shop has two 300-kv.-a. three-phase power transformers, one 140-kw. single-phase lighting transformer, two 325-kw. motor-generator sets and a 7-panel switchboard. This equipment serves this building only. The transformer equipment in the steel storage shed, planing mill and foundry building is practically the same in each, and consists of two 300-kv.-a. power transformers, one 50, 60 or 125-kw. single-phase lighting transformer, and one three-panel switchboard. The transformers in the planing mill supply that building only, but those in the steel storage shed supply the forge shop and the boiler and shipfitters' shop, and those in the foundry building supply the car shop, galvanizing plant, lumber-storage shed and roundhouse.

All distributing cables are run through the shop tunnel in ducts laid in that wall and are then brought up through manholes in the floor of the buildings. From the manholes cables are run in galvanized iron conduits fastened to the roof trusses or carried on T-iron supports attached to the steelwork of the buildings above the lower chords. Drops are run down the building columns to controllers, panel boxes, etc. On account of limited space, the central switchboards were not arranged to permit control of all power and lighting circuits at the boards; instead of this, junction boxes were installed in each section of the shop, from which the power and lighting circuits for that section are distributed. The transformers are connected to the main substation by a single loop feeder-circuit which has ample capacity to carry the normal shop load on one side, in case of emergency. When the valve- and gate-operating machinery on the north wall of the dry dock is installed, it will be connected to the shop transformers.

Four types of motors were adopted for power drives: Direct-current, commutating-pole, variable-speed motors; slip-ring induction motors; squirrel-cage induction motors, and synchronous motors. Direct-current motors operate on 220-volt current, and alternating current motors on 220-volt three-phase 25-cycle current. The direct-current motors drive lathes, planers, boring machines, milling machines and other tools where a variable tool speed is desired. They have speed ranges from 350 to 1400, 375 to 1125, 375 to 1500, 450 to 1800, and 500 to 1500 r.p.m. The slip-ring, polar-wound rotor inductor motors drive machines that require a high starting torque or that are necessarily reversible; as, for example, bending rolls, low-pressure blowers, the 2-ton Tropenas converter and the transfer table. The squirrel-cage induction motors are used for all group drives and on all group drives and all constant-speed machines. The synchronous motors are used for driving direct-current generators and air compressors and are arranged for operation at 75 per cent. leading power factor for correcting the load factor of the plant. All motors were purchased under specifications calling for specially developed insulation similar to that used on the lock-machinery motors.

Lighting for the shops is obtained from tungsten filament lamps, and general illumination is used throughout. This method was considered preferable to special intensified illumination at each machine or in particular sections of the shop on account of the fact that, as all points received approximately the same amount of light, no change in wiring or the position of lamps is required if the arrangement of machines is changed. Lighting is all on 110-220-volt single-phase circuits. Feeders run from the lighting transformers to panel boxes placed at convenient points throughout the shop, and from these boxes the lights in the individual sections are controlled. Branch circuits are designed for a maximum load of 3000 watts, with a drop of 3 volts.

Burning Fine Anthracite and Bituminous Coal

FUEL conditions during the last two years have been such that the users of coal for power generation have been glad to obtain any grade possible in order to keep their plants in operation. In many instances the practice of mixing what is known as anthracite screenings and bituminous coal has been employed by operators of hand-fired furnaces equipped with natural draft.

Those who have never burned such a mixture might imagine that the difficulties in burning anthracite screenings with a natural draft would be such as to prohibit their use. Experience, however, has shown that they give satisfactory results when properly mixed with bituminous coal. Anthracite coals below buckwheat sizes are valuable for fuel as they contain almost as much carbon as the larger sizes and but little more ash and sulphur. They are, however, difficult to burn with natural draft and should, therefore, be mixed with some soft coal.

When burning a mixture of fine anthracite and bituminous coal, the percentage of screenings will vary, depending upon the grate and the draft. Six or seven parts of anthracite dust to one of bituminous coal makes a fuel that burns well. Increasing the proportion of soft coal makes a quick fire, but produces more smoke. Excellent results can be obtained with 25 to 30 per cent. of small-sized anthracite and 70 to 75 per cent. of soft coal. The mixture will give a hot fire, but will produce some smoke. A mixture of half-and-half fine anthracite and bituminous coal can be successfully burned in a furnace having a good draft.

It is important to thoroughly mix the coal before firing. This is best done by bringing it into the boiler room in a wheelbarrow or by other means, dumping

first one load of one kind and then one of the other kind in a pile on the floor and turning the pile over several times somewhat as concrete is mixed. If the mixing is done properly, the firing method need not be changed from that employed in burning soft coal.

Regardless of what mixture is burned, all cracks in the boiler settings should be stopped to prevent air from leaking into the furnace. If a damper regulator is installed, it should be allowed to operate the damper in the smoke connection to the chimney for the control of the steam pressure. Some firemen have the habit of opening the furnace doors to admit cold air over the fire to prevent the boiler from making steam too fast and at the same time allow the damper and ashpit door to remain wide open. The furnace doors should never be left open for any such purpose. If the damper is not in working order, it should be put in shape so that the draft can be controlled by it rather than by means of the ashpit doors. Frequently, the damper regulator is out of order. If this is the case, it should be repaired and connected with the damper so that it will automatically regulate the draft and steam pressure. Arrangements should also be made so that the damper cannot close tight and thus shut off the draft altogether.

As regards the furnace, the grate bars should contain up to ½-in. air space, which is suitable for burning fine anthracite and soft coal. As the anthracite bakes with the soft coal and forms into coarse particles, it will not fall through the grate. To obtain the best results keep the fuel bed level and not too thick; between 5 and 10 in. is considered good practice. It is well to watch for holes in the fire and keep them filled, otherwise an excessive volume of air will pass into the furnace.

In handling a fire the fireman should not disturb the fuel bed too often, as this mixes the ashes with the fuel and causes clinkering. If shaking grates are used, the ashes can be freed from the fire by frequent shaking down, but it is advisable to stop shaking as soon as live coals begin to fall through the grate. After firing, the fuel bed should be left alone and the fire tools should be used as little as possible.

It may be necessary to employ a slice bar if stationary grates are used; and if so, it should be run in under the fire along the grate. Moving the bar back and forth a few times will sift some of the ashes through the grate. If the soft coal is of the coking kind, it may be necessary to slice the fire occasionally so as to break the crust, but care should be taken not to mix the ashes with the burning fuel.

As clinkers and some ash will not pass through the grate, the fires must be cleaned at intervals. The periods will be governed by the proportion of ash in the coal and its character, also by the kind of grate used. A stationary grate will require more frequent cleaning than one of the shaking type. When cleaning a fire, carefully remove all clinkers and ash.

Various methods are used in cleaning fires. One that gives satisfactory results is as follows: Burn down one side of the furnace as much as possible and still keep up the steam pressure during the cleaning period; then wing the live coals to the active side of the grate and with a hoe pull the refuse out of the furnace and into a wheelbarrow. Having cleaned one side, evenly spread some of the live coals from the uncleaned side of the furnace on the clean grate and cover lightly with fresh fuel. When the clean side of the furnace has been built up, the dirty side is burnt down and cleaned in the same manner.

In case a light fire is being carried, it will be necessary to build up one side of the furnace to have enough live coals to cover the grate on the side that has been cleaned. With a boiler that is not being pushed hard, it is possible to burn practically all fuel to ash on the side that is to be cleaned.

Another method of cleaning fires with dumping grate is as follows: The fire on the side to be cleaned is burnt down and the live coals are brought forward on the front portion of the grate; the rear section is then dumped and the live coals are pushed back on the clean part of the grate; the front portion is next dumped and the live coals are evenly spread and then covered with fresh fuel. After building up the clean side, the other side of the grate is cleaned in like manner. Experience will determine the proper cleaning period for each individual plant.

If the grates are of the shaking type and are properly handled, there will be less trouble from clinkering as the ashes can be shaken into the ashpit. Clinkers are nothing more nor less than melted ash, and their formation can be controlled to a large extent by the manner in which the fireman handles his fires. The more excessive the heat in the furnace the greater the probability that clinkers will form. Furnaces that are run at a low rate, and therefore at a comparatively low temperature, are troubled but little with the formation of clinkers.

As has already been said, stirring the fire and mixing the ashes with the live coals produces clinkers because the ashes, being exposed to the intense heat of the burning coal, are fused into a large mass. Naturally, the grade and mixture of the coal will have much to do with the nature and formation of the clinker. Carrying very thick fires coupled with the stirring of the burning fuel bed is a sure way to produce clinkers.

One may ask why a thick fire will cause clinkers to form. This is because a thick fuel bed offers resistance to the passage of the air through it. Without the free passage of air through the fuel bed, the ashes become heated, and upon reaching the melting point, they fuse together and become a solid mass upon cooling. Therefore, clinkers will be greatly reduced if thin, level fires are carried.

In burning a mixture of anthracite and bituminous coal, it is generally not economy to burn anthracite containing more than 20 per cent. of bone and noncombustibles. Furthermore, in many plants the expense of disposing of the ashes would offset the gain made in burning the mixture. One plant may find that a certain mixture is cheaper than another; the second may find that still another mixture is less economical. Each engineer who plans to burn mixed coal should try various mixtures and then stick to the one that gives the best results with his particular equipment.

Testing Single-Phase Watt-Hour Meters Using a Rotating Standard

by
P. B. Findley

While direct current is in general use in smaller plants and for special service such as adjustable-speed motors, the growing plant finds that alternating current, with its economical distribution, is preferable. Hence a knowledge of the construction, maintenance and testing of alternating-current instruments is essential to the well-informed operator. This article considers the single-phase watt-hour meter, used on distributing circuits and the method of testing it, using an indicating wattmeter. A subsequent article will discuss the testing of single-phase watt-hour meters with a rotating standard.

ESSENTIALLY, the single-phase watt-hour meter consists of a light circular aluminum disk *D*, Fig. 1, mounted on a shaft which turns in practically frictionless bearings. At one part of its area this disk comes under the influence of an electromagnet *P* which is connected across the supply line and is known as the

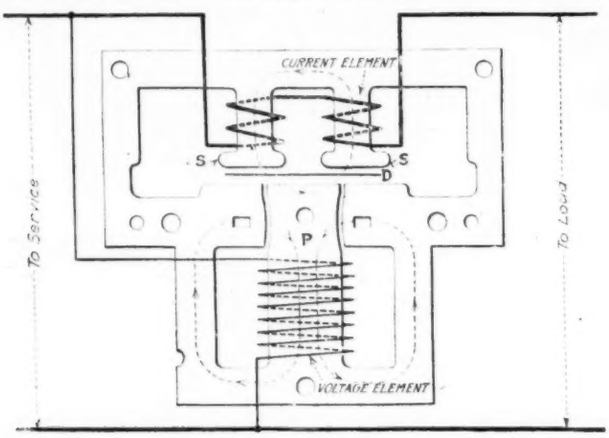


FIG. 1. SCHEMATIC DIAGRAM OF SINGLE-PHASE WATT-HOUR METER

voltage or potential element. Another electromagnet *S* is connected in series with the load and is called the current element. As a result there is a turning force upon the disk which is proportional to the power consumed in the circuit. The rotation of the disk is retarded, precisely as in the direct-current meter, by the magnetic "drag" of two permanent magnets whose lines of force are cut by the disk at a part of its area other than that covered by the electromagnets. The speed of rotation is proportional to the rate of power flow (kilowatts) through the meter, and the number of revolutions in any interval of time is proportional to the total power (kilowatt-hours) which has passed. The details of a typical single-phase watt-hour meter can best be seen by reference to the headpiece and Figs. 3 to 5 which are views of a type OA Westinghouse instrument. The headpiece shows the instrument complete; the glass cover and nameplate have been removed in Fig. 3. A side view is given of the meter element in Fig. 4, after it has been removed from its case, and the rear of the meter element is shown in Fig. 5. Arrangement of the various parts is shown in the figures. An aluminum mounting frame *F* serves as a foundation for the meter element. To it are attached the iron punchings *M* which form the magnetic circuit and carry the current coils *C* and voltage coil *P*. Projections from the frame also carry the upper and lower bearings for the moving element. The lower bearing is shown at *B*, Fig. 4; the register mechanism (located at *R*) and dials *I* are also mounted on projections from the frame *F*. The disk *D* is made of a circular sheet of aluminum fastened to its shaft.

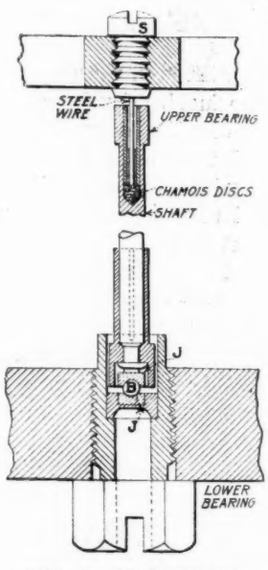


FIG. 2. WATT-HOUR METER BEARINGS

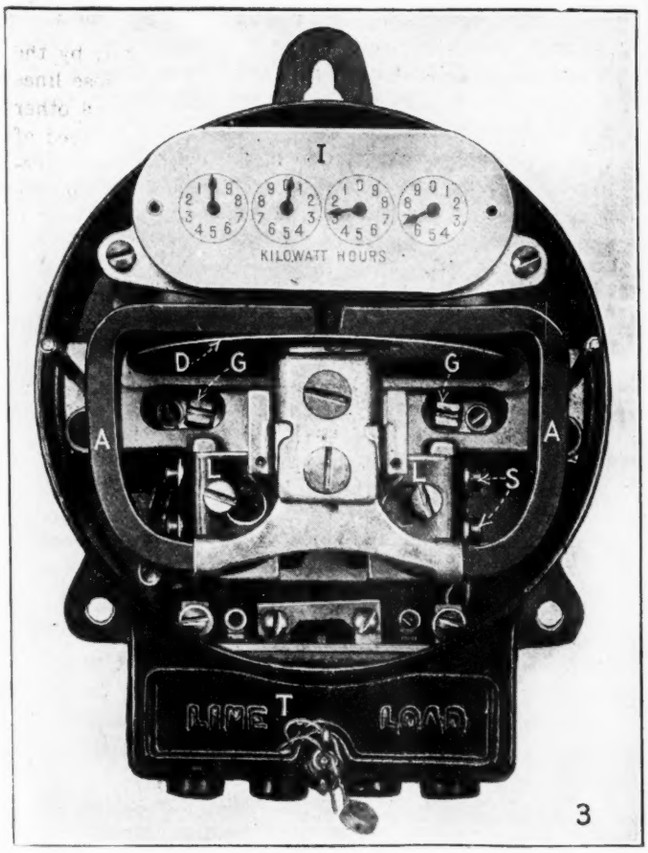
The upper bearing consists of a steel wire, Fig. 2, projecting from a screw *S* which is held in the mounting frame. This wire enters a bushed hole in the upper end of the disk shaft, and at the bottom of the hole are a number of chamois disks moistened with jewelers' oil.

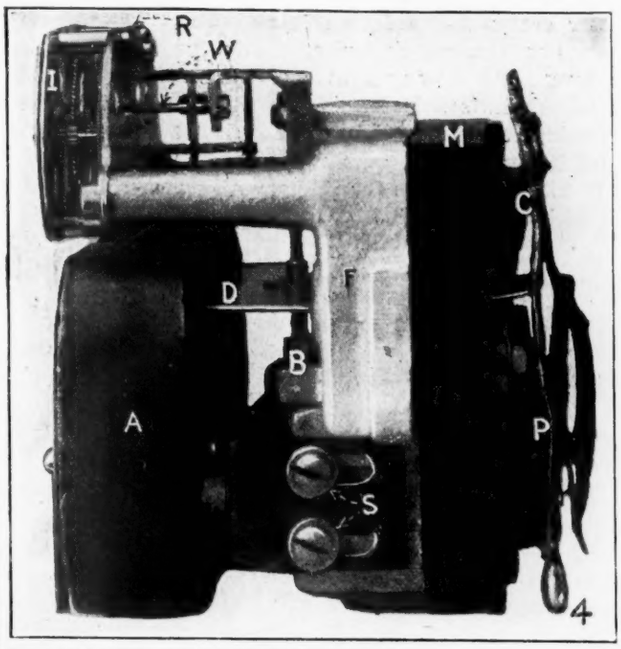
The lower bearing *B*, Fig. 4, whose permanency is vital to the accuracy of the meter, is shown in section

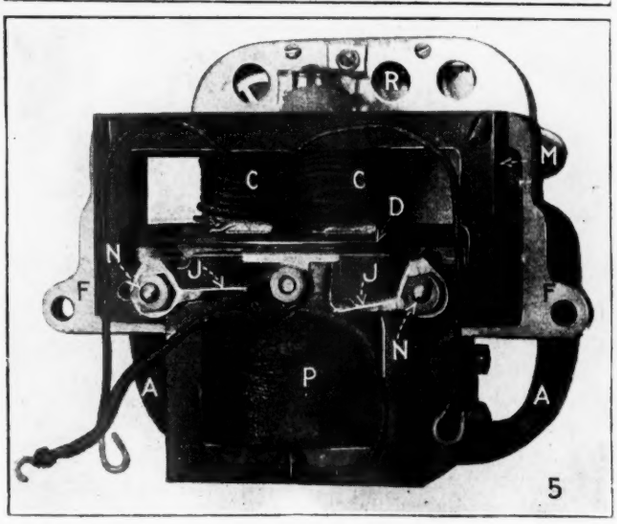
in Fig. 2. This bearing consists of two concave jewels *J*, one fixed to the disk shaft, and one in a screw plug in the frame. Between these jewels is a steel ball *B*. This type of bearing is not liable to be affected by long use and vibration. The permanent magnets *A*, Figs. 3 and 4, are fastened to L-shaped punchings, which in turn are secured to the frame by the clamping screws *S*.

The adjustment of a modern watt-hour meter is a job which can be performed easily by a careful man with the tools of an average electrician's kit. Assuming that we have before us an instrument of the types illustrated, the procedure would be as follows:

Disconnect the meter from the circuit after placing jumper wires to carry the current load. This may be done on the type of meter under discussion without making the line dead by first connecting the wires *B* and *C* and then *A* and *D* together by jumpers, as shown in Fig. 6, after which the screws *S* are loosened one at a time and the connections pulled out and taped up as shown in the figure.







FIGS. 3 TO 5. ASSEMBLY VIEWS OF SINGLE-PHASE WATT-HOUR METER

After the meter has been disconnected from the circuit, remove the cover and spin the disk with the finger, noting how long it takes to slow down and stop. Make sure that the disk rotates freely and that it or the shaft has not been bent. This might happen from damage in shipment or from a severe short-circuit.

If it seems necessary, remove the register mechanism *R* by taking out the screws *E*. See that the shafts of the indicators and gears have a small amount of longitudinal play and move easily in their bearing; make sure that all are straight and that no oil is on the worm or its gear. The worm and gear is shown located at *W*, Fig. 4. If the disk does not turn freely after the indicating mechanism has been removed, the meter should be repaired. This is not a difficult task in a properly equipped shop, but detailed instructions should be secured from the manufacturer of the meter.

Sometimes it will be found that the shaft rattles in its bearings when the meter is alive. This is due to the shaft having the same natural frequency of vibration as the frequency of the circuit. Usually, the trouble can be corrected by putting in a new top bearing.

The inside of the meter and cover should be thoroughly cleaned before the cover is replaced.

After inspection, the meter is put on full voltage with no load on the current coils. This can be done by connecting up the two line terminals as shown in Fig. 7. The "light load" adjustment is moved by turning the square-head screws *G*, Fig. 3, until the disk does not "creep" in either direction. Practically, this test is made by giving the disk a very gentle push, first in one direction, then in the other, with the finger. It should not continue to rotate in either case.

The light-load compensator in the meter under consideration consists of two metallic loops which pass through the air gaps in the voltage coil's magnetic circuit. They can be seen at *J* in Fig. 5, being clamped under the large hexagonal nuts *N* to right and left of the polepiece of the voltage coils. By turning with a screwdriver the large square-head screws *G*, Fig. 3, these loops are made to move in the air gaps. If the meter creeps forward or is fast on light load, both screws are turned clockwise, and if the meter creeps backward or is slow on light load, both screws are turned counterclockwise. Before doing this, the round-head clamping screws should be slightly loosened and afterward tightened.

It will generally be found that if the meter does not creep, it will be correct on light load; that is, 10 per cent. full load. However, the latter condition is the one for which adjustment must ultimately be made.

The full-load adjustment is made by changing the position and hence the damping effect of the permanent magnets *A*. By moving them in toward the shaft, their effect is decreased and the meter will run faster; by moving them out, the meter will run slower. Each manufacturer provides differently for this, but inspection will show how it should be done in any given meter. On the meter shown, the full-load clamping screws *S*, Fig. 3, are loosened slightly, and each magnet is moved in or out by its adjusting screw *L*. The screws *L* have a shoulder below the plate through which they pass that pushes out this plate and the attached magnet; the screw-head pushes them in. After final adjustment the clamping screws are tightened. About one-half the change in adjustment should be made by motion of each magnet.

It may be desired to check the full-load adjustment at low power factor when the load is one which operates much of the time at low power factor. Such a load would be one of induction motors running light or of unloaded transformers. This test is not generally made in the field by central stations, but only in the shop. Many watt-hour meters are constructed and set at the factory to be accurate at unity and at 70 per cent. power factor and no adjustment is provided. This is true of the meter illustrated.

The lag adjustment, when furnished. consists of a small coil of copper wire wound around the voltage-coil polepiece. This coil is short-circuited through leads of variable length, which are used to control the resistance of the coil. Variation to secure accuracy at low power factor usually changes the calibration at unity power factor and hence a check test should be made at full load and unity power factor, with adjustment if necessary.

Any alternating-current instrument or combination of instruments which measure electric power and time can be used for calibrating alternating-current watt-hour meters. The simplest combination is a voltmeter, ammeter and stop watch, used on a circuit of unity power factor; that is, a resistance load as indicated in Fig. 8. The resistance may be either a water rheostat or a bank of incandescent lamps. As there are three instruments to be observed, and as unity power factor is the exception in alternating-current work, this method is not always practical.

A satisfactory arrangement is an indicating wattmeter and a stop watch, particularly when an accurate wattmeter is already part of the electrical equipment. A switchboard instrument is not considered sufficiently accurate for this purpose. In making the test with a wattmeter, the potential coil of the wattmeter is connected across the potential coil of the watt-hour meter under test, and the current coil in series with that of the watt-hour meter, as in Fig. 9.

When the desired load on the watt-hour meter has been secured, the disk will turn in the direction marked by the manufacturer. While the helper holds the power indication of the wattmeter constant by varying the rheostat, the tester times a certain number of revolutions of the watt-hour meter disk. The time should be between 30 and 60 sec.; since a stop watch is accurate to only 0.2 sec., the longer the time the less the percentage error in reading.

The formula for the error of the watt-hour meter is

$$E = \frac{3600 K_h N \times 100}{PT} - 100$$

where

E = Per cent. error;
3600 = Number of seconds in an hour;
K_h = Watt-hour constant of meter = watt-hours for one revolution of disk:
N = Number of revolutions in T seconds;

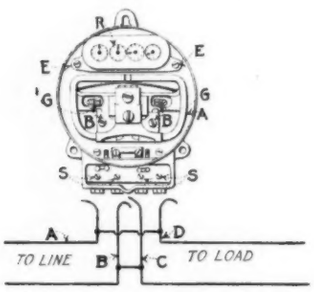


FIG. 6

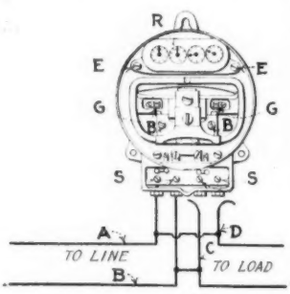


FIG. 7

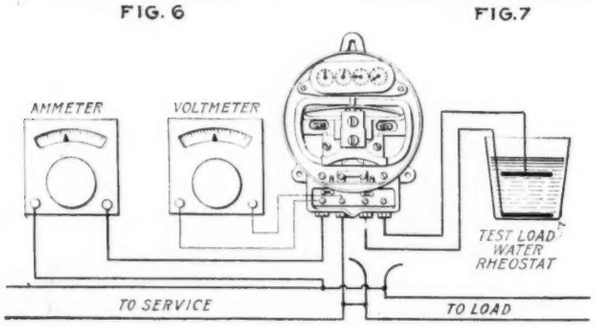


FIG. 8

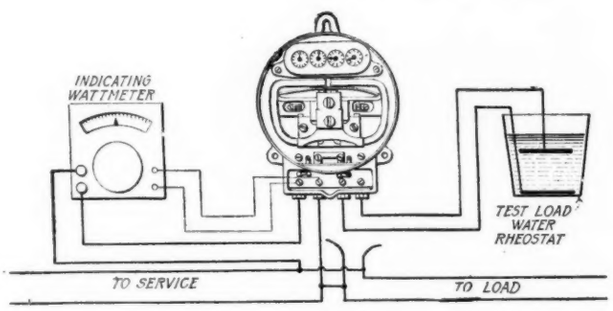


FIG. 9

FIGS. 6 TO 9. CONNECTION DIAGRAMS FOR TESTING SINGLE-PHASE WATT-HOUR METERS

P = Watts flowing through meter.

The watt-hour constant K_h depends on the make, type and capacity of the meter. It is found on a Westinghouse meter on the inside of terminal chamber cover, where are marked revolutions r of the moving element for a given number of kilowatt-hours P from which $K_h = \frac{P}{r}$.

For a concrete example assume that we have on test the meter shown in Fig. 3. This instrument is rated at 60 cycles, 100 volts, 5 amperes for two-wire service. On the inside of the terminal chamber cover T, Fig 3, we find, one revolution of moving element = 0.333 kw.-hr.; that is, $K_h = 0.333$, or 1/3. Our first test, at no load, shows that the meter creeps slowly forward. By moving the light-load adjustments we correct this, and then take a set of three readings at 50 watts, for the time of three revolutions. The average of three readings is 71.3 sec. Substituting in the formula, we have

$$E = \frac{3600 \times 0.333 \times 3 \times 100}{50 \times 71.3} - 100 = 0.98,$$ or about 1 per cent. fast, which is near enough.

The load is now set at 500 watts, and the time of 20 revolutions taken. The average of three readings assume to be 46.1 sec., which gives

$$E = \frac{3600 \times 0.333 \times 20 \times 100}{500 \times 46.1} - 100 = 4.1,$$ or 4 per cent. fast; therefore, we move the magnets outward a small amount and take another set of readings. This time assume we get 47.6 sec. for 20 rev. and $E = 0.84$, or less than 1. Another very small movement of the magnet would set the meter as nearly correct as the accuracy of our observations would justify attempting.

There are several points to be noted in the foregoing tests. The value for P is true watts flowing. The wattmeter reading will usually be different from this, its error being given on a curve accompanying it, which is corrected each time it is calibrated. Before making the test, the wattmeter potential circuit is opened, and the pointer, if not on zero, is set so. The position of the pointer for the desired load is then obtained by adding to or subtracting from the scale reading the amount of correction shown on the calibration curve, and the load is regulated to hold the pointer at that mark, regardless of voltage fluctuations. This may be done by a carbon-block or slide-wire resistance in parallel with the "fixed" part of the load.

By solving the foregoing formula for T, putting $E = 0$, we find that if the meter is exactly right (zero error), for a load $P = 500$ watts, and time T for 20 revolutions

$$T = \frac{3600 K_h N}{P} = \frac{3600 \times 0.333 \times 20}{500} = 48 \text{ sec.}$$

For the preliminary rough tests while setting the magnets, we can then simply try to get T as near 48 sec. as possible and work out the actual error only when satisfied that we can come no closer.

The accuracy of this method depends on how closely the wattmeter indication is held constant. This depends on the steadiness of the voltage and on the proficiency of the helper in manipulating the rheostat. Sometimes an isolated generator or a lightly loaded one can be secured. In general, the difficulties of the foregoing method have caused it to be superseded by a rotating standard. The use of a rotating standard for testing alternating-current wattmeters will be described in a subsequent article.

Wastes Due to Leaky Boiler Settings

By HARVEY G. HAYS

There are in most steam plants wastes that can be reduced to some extent. One source of loss is air leakage through the boiler settings, which can be practically prevented if the engineer will carry out the suggestions made in this article.

ERECTING a boiler is similar to erecting a steel-framed building. The boilermaker sets up his iron supports and hangs the drums and tubes with the necessary piping connections. When this is done, the brickmason comes and the boiler is inclosed. The purpose of this brickwork is to form the inclosing ducts for the heated gases while the boilers are absorbing the heat. It is the office of the chimney to furnish the draft which causes the air to flow into the furnace through the fuel bed and through the passages in the boiler where the heat generated by the combustion of the fuel is absorbed by the water and converted into energy.

In order to properly perform its function, two things are essential in the brick setting: It must be tight so that the air will be forced through the fuel bed and cause it to come into contact with the combustibles. It must also force the heated gases to travel in the paths laid out by the boilermakers so that as much of the heat as possible may be absorbed by the water within or around the tubes.

When a boiler is in service, the gases in the boiler passes and inside the chimney are heated. They are accordingly lighter than the air surrounding the boiler setting and the chimney. The tendency is therefore for the heavier cold air to push into the boiler setting through every opening, crack, crevice or pore in the brickwork, as well as through the grates and up through the fuel bed, where it was intended that the draft should cause it to flow. Regulation of the flow of the air through the fuel bed, important as it is, will not be mentioned here but only the excess air which gets in through leaks or pores in the brickwork or is not properly "routed" in the boiler passages.

Expansion and Contraction

Every substance expands and contracts under changes in temperature. In each 180 deg. iron changes one part in 800 approximately, while firebrick changes only one part in 2000. The result is, of course, that when the boiler is fired up, the ironwork expands more than the brickwork, which is slightly moved when the iron expands. When the boiler cools and the ironwork shrinks, the brickwork stays where it was pushed, and the pro-

cess is repeated when the boiler is fired again. Cracks are developed in this manner, and inasmuch as these conditions continue as long as the boilers are in service, it is necessary that the engineer or whoever is in charge be continually on the watch to keep the settings tight.

Few engineers realize the loss for which a leaky setting may be responsible. Combustion engineers place the average loss at 10 per cent. and report finding it as high as 20 per cent. in extreme cases. Whatever the loss, it is preventable and is inexcusable, for the air which finds its way into the boiler passages through the brickwork does no good as it does not promote combustion, but serves to absorb the heat.

Most engineers will tell you that their boiler settings are tight, in good shape or fair. Few will admit that they need attention. Occasionally one will own up that he knows they are "rotten," but amplifies by stating that next spring they are going to reset the boilers and there is no use doing anything to them now.

Boiler-Setting Leaks May Be Readily Located

It is easy to locate the boiler-setting leaks if they are gone over with a lighted candle and every crack tested that looks suspicious. In most cases the flame of the candle will be drawn into the crack. Sometimes the candle will be snuffed out. A leak of that caliber is responsible for an appreciable waste of fuel. Another "eye-opener" for the engineer is to have him throw a scoopful of green coal on the fire and close the boiler damper tightly. By watching where the smoke comes out one can be assured that wherever smoke issues air enters, because the conditions have been reversed and the pressure is inside instead of outside the setting.

Another source of leakage commonly overlooked is in the division walls between boilers set in batteries. These walls are carelessly laid up many times. It is difficult to properly inspect them, and on the theory that "what a man doesn't know doesn't hurt him," the average engineer usually passes them by. If the boiler happens to be "down," however, the leak is just as serious as if the leaks were in an outside wall. The live boiler will draw cold air from the dead one, and fuel will be wasted.

Leaks Where Iron and Brickwork Meet

In looking for leaks, examine every point where iron and brickwork meet. See that the fronts are tight and not warped and sprung away from the brick backing, and that the clean-out doors fit tightly. If the boiler is of the water-tube type see that the headers are properly packed and be sure that the doors covering them are closed tightly. If the headers have hollow stay-bolts, make sure that these are plugged and kept so. Examine the "dead plate" in the fire-door and see that there is no passage to the ashpit below. Carefully examine every suspicious crack and test it with the flame. Make sure that all the air drawn into the boiler is drawn in through the fire bed. When sure that all leaks have been located, it would pay to have someone test the flue gases with a gas analyzer if the plant is not supplied with the apparatus and make sure that nothing has been overlooked. Keep after the leaks until the gas analyzer shows the same percentage at the front passages as at the back passages, and then it is reasonably sure that the settings are tight.

Do not conclude that because a crack looks small there is no leakage. Indeed, there may be an appreciable infiltration and no crack at all because dry brickwork is porous. Throw a brick into a pail of water and see how quickly it absorbs the moisture. The only safe way is to cover the boiler settings and be sure to flush up to all ironwork and calk all large cracks before applying the coating. Whitewash with glue dissolved in it makes a good covering and smokestack or roofing paint is sometimes used; coal tar answers the purpose temporarily. There are a number of special coverings made for this particular purpose, composed of asphalt, asbestos and certain drying oils and so mixed as to retain their elasticity for a longer time than the cheaper substitutes mentioned. Anything that will seal the pores and stop the cracks will answer the purpose.

Asbestos Plaster the Best Covering

If the best kind of a job is desired, apply a good quality of asbestos plaster over the setting and put it on at least two inches thick. Cover this with a layer of canvas and give the canvas a good coating of paint. The boiler will then be insulated as well as sealed and will increase the efficiency by retaining most of the heat.

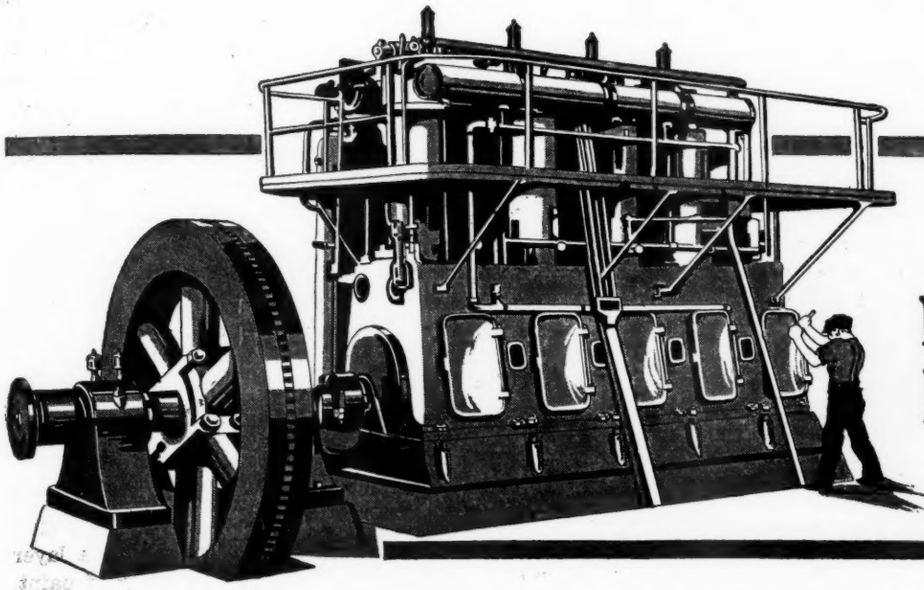
If the boiler is of the ordinary return-tubular type and measures have been taken as suggested, that is about all that can be done in cutting out wastes from leakage. With a water-tube boiler, however, it will be necessary to inspect the baffles to make sure that the heated gases are compelled to travel in the paths laid out for them. The baffle tiles are made of fire clay and are hung on the tubes in a water-tube boiler for the purpose of lengthening the path of the gases and making them come into contact with as large a tube area as possible. This gives the water in the tubes an opportunity to absorb as much heat as possible and reduces the temperature of the escaping stack gases.

Inspection of Baffles

If the baffle tile are broken or burned away, the hot gases will not travel by the long path laid out for them, but will take the shortest route for the chimney and may miss more than half the heating surfaces. The result is that the heat is not extracted from the gases, but passes up the chimney and fuel is wasted. A flue-gas thermometer is a handy instrument for detecting these conditions. A better way is not to allow them to occur. This will mean that somebody will have to crawl into the boiler and carefully inspect the baffling whenever the boiler is down, and that somebody sees that a supply of tile is kept on hand with which to make repairs.

Sometimes, but not always, the engineer is responsible for the conditions referred to in the foregoing. Often the engineer is required to do so many things around the plant that he does not find time to look after the boiler settings. He may know it should be done and intend to do it when he has the time. Ordinarily, he does not appreciate how expensive his delay is.

The shortage of coal in Denmark has led to high prices being paid to people to work in the peat bogs. It is no unusual sight to see students, military officers and others digging industriously in such places.



Talks on DIESEL Engines

by L. H. Morrison

IV—The chief describes various types of connecting-rods and the methods used in adjusting them. He also explains how piston pins should be ground and lapped.

WHEN the men came together again for their discussion of Diesel-engine troubles, Kelly was quiet and subdued. This mood was so unusual that J. R. twitted him about it. As he had expected, he got a rise.

"It begins to look as though I'd have to rebuild the whole engine," Kelly complained. "It has an old-style connecting-rod like this"—he opened a dogeared instruction book and pointed to a sketch like that shown in Fig. 1. "The manager saw one somewhere with a wedge adjustment on the piston-pin end, and now he wants me to change this one. It's a job I can't do; and what's more," he added, "I don't believe the machine shop can, either."

"It was bound to come sooner or later," Egan consoled. "But begin early—sit down on him."

Kelly looked relieved, and Egan went on:

"As I recall, that type of engine was originally built with the type of rod shown in Fig. 1. The big end is like that generally used at the present time, but the little end or piston end has a modified marine box. In later engines of American make the piston end was fitted with a wedge adjustment along the lines of Fig. 2.

"In making adjustments I'll agree that the wedge is handy, since the piston and rod need not be removed from the engine. In fact, it is too easy to adjust, for often the engineer will draw up on the bolts when it is the big end that is knocking. This feature could be overlooked if there wasn't a strong tendency for the wedge bolt to break. I know of a number giving way under heavy load. Of course the wedge is common practice on steam engines, but the manner of application is different. In a steam engine the wedge is vertical, and since it can be longer, the angle of the wedge can be less. In the oil engine the wedge can't be placed at right angles to the pin axis, because there wouldn't be room for a wrench inside the piston. Consequently the wedge is placed parallel to the pin. It must be very short, being only the width of the flat rod end, and the wedge angle is steep to give a considerable raising effect for a small lengthwise movement of the wedge."

"What makes the wedge bolt break?" one of the men asked. "I got the idea there wasn't any explosion in a Diesel engine."

"That's right," answered J. R. "The Diesel is not an explosion engine; but still there's a blow given to the piston at the beginning of the oil injection. This blow is taken by the piston pin and the wedge gets the full effect of it. Since the wedge angle is steep, a large part of the blow is absorbed by the wedge bolt. These repeated shocks cause crystallization of the bolt and finally it fails."

"I don't agree with you that the wedge type is easy to adjust," Kelly broke in. "It's darn hard to put in the shim between the two brasses."

"You are about right," confessed Egan. "However, you'll find a good many men who don't insist on taking up the play by changing the shims. Some use the wedge exclusively; but it's these fellows who are always breaking wedge bolts.

"A new design of the wedge type, like this"—Egan opened a catalog of a horizontal engine and pointed to an illustration similar to that in Fig. 3—"does away with shims by using adjusting screws to take up the wear, the wedge serving as a support."

"I think the hardest part is to judge just how tight to draw up on the wedge," offered Woods, the new oiler.

"That is one thing that an operator can learn only by experience," replied the chief. "Each engine will require a different amount of play. As a rule I believe the wedge should be drawn up tight and then slacked off about an eighth turn of the

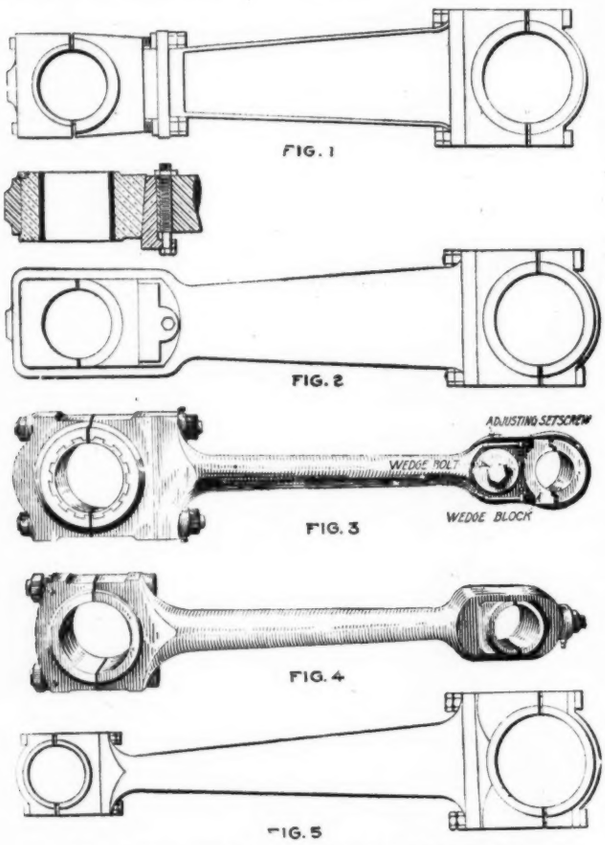
The next article takes up the discussion of the relative advantages of A frames and box frames, with some side remarks by Egan on cooling hot bearings

wedge bolt. There will be enough in the shims to allow this."

"That applies to wedges; but how about the other types without wedges?"

"In the other types the brasses should be allowed enough play to enable a man to swing the connecting-rod with a small effort. In adjusting rods like those shown in Figs. 4 and 5, drive out the pin, so that the rod can be withdrawn from the piston. Then fit the pin to the rod by removing the correct amount of shims. If a setscrew is used, as in Fig. 4, draw this down snug. The piston, rod and pin are then assembled, and the connecting-rod swung by hand to see if the brasses are too tight. Since all this requires removal from the cylinder, it takes some time, but you know you have the adjustments correct.

"When you turn to the big ends, you will find every up-to-date manufacturer using the marine type with



FIGS. 1 TO 5. FORMS OF CONNECTING-ROD ENDS

the babbitt cast directly onto the steel housing. If you ever have to rebabbitt the big end, you'll find it as easy as running a main bearing, and the procedure the same, including heating the steel housing before running the babbitt. Another thing worth remembering is to use plenty of shims so that the box can be taken up a good deal before it needs to be replaced."

"What about the clearance between the bearing faces and the crank web?" inquired Kelly.

"Like all adjustments, this varies in different engines; but around seven-thousandths on each face is about right."

"In adjusting one of the big ends on No. 1 engine last Sunday, I calipered the diameter, and it seemed that the bearing was worn more on one end than on the other. Why is that?" queried the oiler who was working in Kelly's place.

"You'd best ask a wiser head than mine about that," laughed the chief. "I do know that in almost all vertical Diesel engines the wear on the crankbox is greater on one end than on the other. In fact, frequently one end will show a remarkable wear immediately after being adjusted. More often the ends wear faster than the center, causing the bearing to become bell-mouthed. While we don't know the reason, we do know it exists and should guard against the consequences. In engines having seen considerable service, the neglect of this feature may cause extensive cylinder wear on one side and require the cylinder to be rebored much sooner than would otherwise be the case.

"While we are discussing big ends, I might call your attention to the fact that you should caliper the crankpins at least every six months. There is always a likelihood of the pins wearing flat. To remedy this the engineer must file the pin and then finish up by doing a careful job of lapping.

"Another detail you should attend to each time the pin is calipered is to examine for surface fracture. The majority of broken crankshafts have failed at the junction of the pin and the crank web. So remember to wipe the pin and web perfectly clean and examine the entire circumference with a magnifying glass."

"Mr. Egan, why are the piston pins and the bosses on the piston ground to a taper seat? On the hot-ball engine I ran, the pin wat straight and the bosses were only bored." It was Woods who put the question.

"Woods, that feature is one of the many that differentiate Diesel-engine workmanship from that found on hot-ball engines. As to why the taper seat is used, let us recall what we discussed about the hammer blows breaking wedge bolts. If there is any play between the pin and its seats in the two bosses, the shock will cause the pin to wear an elliptical seat in the bosses. If a straight pin was used, it would be impossible to get an absolutely tight fit in the bosses; but by using a taper on each end the pin and the seats can be ground together, and if any wear does occur, it can be taken up by regrinding. In fact, regrinding can be done so perfectly that it is impossible to remove the pin without using a sledge and copper mallet.

"To grind the pin without allowing it to stick, lay the piston on two 6 x 6-in. timbers, as shown in Fig. 6, with the pin in a vertical position. Put a spring under the lower end of the pin, strong enough to lift it from its seat, yet allowing the operator to push it back into contact by pressure on the pin wrench. Coat each of the taper surfaces of the pin with emery paste, put the pin into the piston, press down hard enough on the pin to cause it to seat, and rotate it, making a little more than a quarter of a revolution. Gradually revolve the pin, at the same time rotating it back and forth. This will cause every point on a circle of contact to be ground to a perfect seat. A lot of engineers grind the pin by giving it a quarter- or half-revolution only, never completely revolving it. This tends to make the contact surfaces out of round.

"After rotating back and forth a few minutes, release the pressure, move the pin around a little, apply more paste, push the pin back into contact and grind away some more. All the requirements for securing a

good taper fit are patience, a good emery paste and honest effort."

"What grade of emery paste do you recommend?"

"For finishing the job always use the finest of emery paste. Emery flour mixed with good machine oil is very satisfactory."

"That's the very kind I was using last month when

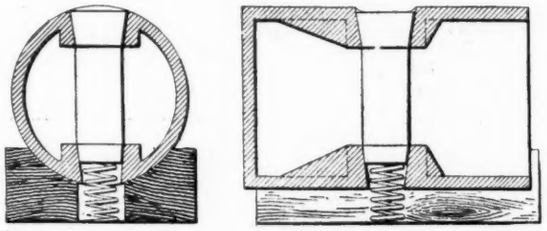


FIG. 6

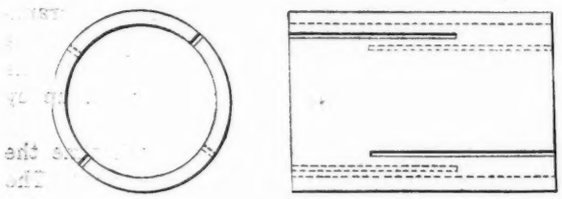


FIG. 7

FIGS. 6 AND 7. GRINDING AND LAPPING PISTON PIN
Fig. 6—Rig for grinding pin. Fig. 7—Sleeve for lapping pin

the chief kicked so hard," one of the day oilers whispered in a loud aside to Kelly.

Egan's sharp ears caught the remark.

"Johnson evidently failed to note I said 'for finishing,'" said the chief. "For starting the job, the condition of the pin will determine the grade of grinding paste. If the pin and bosses are badly out of shape, the quickest and best way is to rough out the seats with coarse emery paste. This will take out all the lines and bring the surfaces to their correct shape. Then the finishing job requires the finer paste.

"Sometimes the piston pin becomes flattened. To bring it back to its original shape, first caliper it very carefully to find out where it is out of true. Then lap the pin, using a lot of patience with the job. This will reduce the pin diameter, so be sure to take out the pin brasses and scrape them to a new fit. There are cases where the pin is so flat that it can't be trued up by any amount of lapping, and the only thing that can be done is to anneal the pin and true it up on a lathe. Then harden it, taking care that, after quenching it in water, the temper is drawn back enough to prevent the pin from being brittle. The pin is now ready for grinding. In case there is no machine shop handy that has a regular grinding machine, the best method is to use one of these motor-driven grinders which can be mounted on the lathe toolpost. A good mechanic should be able to grind within one-thousandth of an inch of the desired pin diameter. This is a job that an ordinary operator should not undertake, and usually the average engineer had best purchase a new pin from the manufacturer."

"Chief," Woods ventured, "you say 'lap' the pin. Now, that's a word I've heard used a lot, but nobody ever explained what it meant."

"Lapping may be defined as rubbing to a perfect surface by means of fine emery paste," said Egan. "For an ordinary job of lapping, a good method would be to apply the emery paste to a cloth and rub the pin briskly, stretching the cloth so that it covers at least half the circumference of the pin. An ideal way is to make a brass collar like that in Fig. 7, as near the pin diameter as possible, and slot it at four points. By placing this on the pin with a small amount of emery paste, it can be rotated and will finish the pin in a most approved manner."

Woods spoke up once more.

"You have been talking about pins with taper ends. Now, I have a number of catalogs of Diesel engines, and it seems to me that a lot of 'em use straight pins."

"Maybe I did give you fellows the idea that all Diesel builders use taper piston pins. Of course, that isn't a fact. Probably as many use the straight pin as use the taper pin. But the tendency now is to use the taper pin, and that is why I thought it best to make mention of that type."

Shunt and Series Windings Opposed

BY E. C. PARHAM

Opposition of the shunt and series windings of a compound-wound generator is not likely to be suspected until an attempt is made to put on a load. If the shunt winding is connected across the brushes, as in Fig. 1, the no-load series-field current will be zero. If the shunt winding is so connected as to include the series winding in its circuit, as in Fig. 2, the no-load series-field current will be the shunt-field current, which will be too small to have appreciable effect through the few series turns. On applying a load, however, the increasing value of the series-field current increases the opposing series-field effect and a load much less than full load will be the limit to which the current can

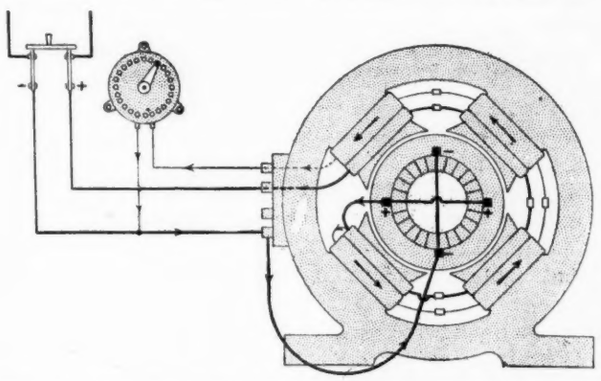


FIG. 1. COMPOUND GENERATOR WITH SHUNT WINDING CONNECTED ACROSS THE ARMATURE

be increased and maintain the voltage at normal value by adjusting the shunt-field rheostat.

Complaint was made that the voltage regulator of an exciter could not maintain the alternator's voltage, because the exciter was too small. An inspector found the field regulator out of order. However, the putting of the regulator into shape did not improve the voltage conditions. The operator said that the trouble could not be in the exciter because he had just temporarily removed it from motor duty which it had been satisfactorily performing for several years. This statement proved to be a clue to the trouble. On

short-circuiting the series-field winding of the exciter, regulation became much better, and on reversing the series-field connections of the exciter, regulation became normal.

The compound-wound motor was being applied to generator duty that called for the same direction of rotation as when used as a motor, and the series-field connections should have been reversed at the time of making the change, but they had not been; therefore

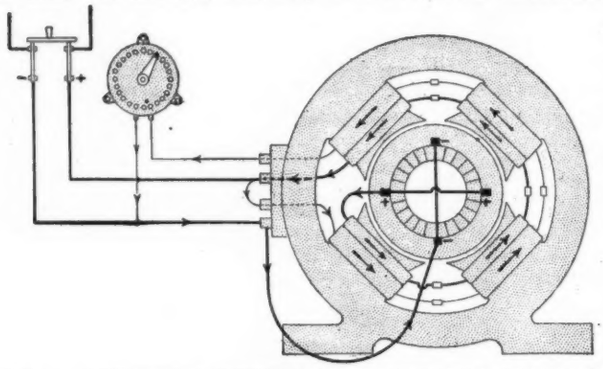


FIG. 2. COMPOUND GENERATOR WITH SHUNT WINDING CONNECTED IN SERIES WITH SERIES WINDING

the shunt-field windings and series-field windings were opposing each other. The best that the regulator could do was to hold the shunt-field rheostat short-circuited, thereby giving maximum value of shunt-field current. Even this maximum value was not sufficient to maintain the voltage of the alternator.

Comparison of Oil and Coal as Fuel

Basing general statements on results obtained in a few isolated cases is a foolish policy and often leads to large mistakes. For example, it would be incorrect—in many instances even absurd—to say that oil fuel is preferable to coal on the grounds of smaller cost of steam produced. Such a statement is true only under certain definite conditions and those qualifying conditions should be included.

As an illustration, consider the fuel situation in southern California. There are no near-by coal fields, and the cost of coal is therefore very high. On the other hand, there is a plentiful local supply of petroleum, and as a result oil fuel is commonly used under steam boilers in that and surrounding regions. Under the circumstances it is the cheaper and is therefore the logical fuel to be used.

In the East, conditions are reversed. Fuel oil must be transported considerable distances, whereas coal fields are well distributed over the entire territory. The result is that coal forms the almost universal fuel, oil being burned only in a few localities to which it may be carried cheaply by steamers.

The whole question of the relative values of these two kinds of fuel for steam generation narrows down to the cost of producing 1000 lb. of steam from and at 212 deg. F. with each. The solution in any particular instance should take into account not only the cost of the fuel delivered in the boiler room, but also the labor cost and the heating value of each fuel.

One of the advantages of using oil fuel is that the number of firemen may be reduced, but this factor becomes appreciable only in the larger plants; for obviously, the small plant containing one or two boilers must have a fireman, no matter whether coal or oil is used. There is the further advantage that oil leaves no ash and consequently the problem of ash disposal does not enter. Because of the better mixture of air and oil spray, the oil-fired boiler may be operated at an efficiency from 5 to 15 per cent. greater than that of the average coal-fired boiler.

As against these advantages it must be remembered that the supply of oil is limited and that any concerted move to replace coal with oil would at once run the price of oil up to a prohibitive figure, because the demand would far exceed the supply.

It is not possible to state, offhand, which of the two fuels is the more economical under certain conditions. The proper thing to do is to calculate the relative costs, based on the heat values of the fuels to be compared.

At present quotations, fuel oil costs from 7 to 15c. a gallon, an average price being 10c. Suppose, for the sake of argument, that the oil weighs 7.5 lb. per gallon, that its heating value is 19,200 B.t.u. per lb. and that the boiler efficiency is 75 per cent. The boiler would utilize $19{,}200 \times 0.75 = 14{,}400$ B.t.u. for each pound of oil used, which would account for the evaporation of $14{,}400 \div 970.4 = 14.84$ lb. of water from and at 212 deg. F. To evaporate 1000 lb. of water from and at 212 deg. F. would require $1000 \div 14.84 = 67.4$ lb. of oil; and as the oil weighs 7.5 lb. per gallon, it would require $67.4 \div 7.5 = 9$ gal., which would cost 90c. In other words, it would cost 90c. to evaporate 1000 lb. of water with oil under the assumed conditions of cost, heating value and efficiency.

Suppose that the coal to be used has a heating value of 14,000 B.t.u. per lb. and the boiler efficiency is only 60 per cent. The boiler will then absorb $14{,}000 \times 0.60 = 8400$ B.t.u. for each pound of coal burned, and will have an evaporation of $8400 \div 970.4 = 8.66$ lb. of water from and at 212 deg. F. To evaporate 1000 lb. there will be needed $1000 \div 8.66 = 115.5$ lb. of coal of the grade specified.

Now, if the oil and the coal were of equal economic value under the assumed conditions, the 115.5 lb. of coal would be worth 90c., which corresponds to $90 \div 115.5 = 0.78$c. per lb., or $15.60 per ton of 2000 lb. Stating this in another way, it may be said that if the given coal costs $15.60 a ton it will give just as good evaporative results as fuel oil at 10c. a gallon; and from this it follows that oil would not prove the more economical unless the cost of coal was greater than $15.60 a ton. From such figures as these it will be seen that oil has no economical advantage over coal except under the most favorable circumstances.

Natural gas carries with it the vapors of gasoline and other hydrocarbons that may be recovered in liquid form by the absorption process. Briefly, this process consists in spraying an absorbing oil downward through a tower and forcing the natural gas upward through the spray. The oil absorbs the gasoline from the gas, which passes out and can be used for fuel. The gasoline is then driven off from the absorbing oil by steam heating and the vapors are condensed, producing liquid gasoline. The absorbing oil, freed of the gasoline, is cleaned and used again as an absorbent.

Some Tests with Flow Meters*

BY JOSEPH A. MAGUIRE

In order to increase plant efficiency actual facts must be known. The flow meter furnishes means for readily obtaining the actual consumption or output of a steam generating or consuming apparatus. The tests here described resulted in the elimination of wastes that were unsuspected.

PRESENT world conditions, necessitating conservation of all resources, have brought to a deserved prominence many pieces of apparatus heretofore incorrectly looked upon as luxuries. Some years ago the flow meter was in this class, but of late power plants in all industries have been straining to their utmost in an endeavor to raise efficiencies and, consequently, the real value of this device has been gradually realized.

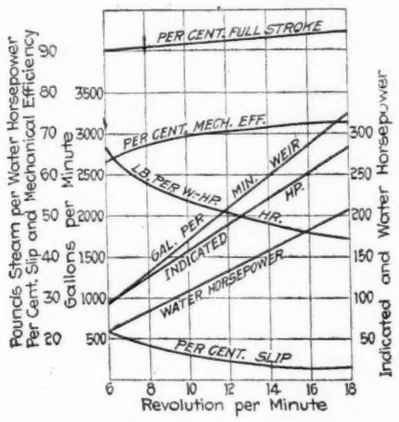


FIG. 1. CHARACTERISTIC CURVE OF DUPLEX COMPOUND CONDENSING PUMP

Steam end, 19 x 36 x 36 in.; water end, 21 x 36 in.; head, 248 ft.; suction, 10 ft.; steam pressure, 125-140 lb.; Scranton jet condenser vacuum, 22-24 in. Steam curve includes losses in 1460 ft. of 8-in. main and 68 ft. of 5-in. main.

Considerable prominence has been given to the use of the flow meter in boiler rooms of manufacturing industries, central stations, etc., but its application to mine power plants is practically an untouched subject. The present article is an account of operations in this field.

A short time ago a number of collieries operating 36 boiler and power plants were thoroughly investigated by their owners and engineers. These men had foreseen the coming coal shortage and were preparing to meet it not only through increased production, but by conservation in their own plants. Flow meters were installed as a means of obtaining the required information.

The testing equipment at first consisted of four flow meters, the necessary mechanisms and an assortment of nozzle plugs and pipe reducers. Later, eight more meters of the same kind were added. After a preliminary survey of the entire layout it was evident that the pumping situation was the most serious and needed immediate attention. The first pumping plant investigated, located 250 ft. underground, consisted of four simple duplex direct-acting noncondensing pumps, each of 2000 gal. per min. rated capacity, and two duplex compound condensing pumps, each of 4000 gal. per min. capacity. The condensing pumps were equipped with low vacuum jet condensers. These six pumps were located in three adjoining pumprooms, two of which were partly submerged during periods of high water.

Steam was supplied from a modern boiler plant on the surface, at a distance of 2500 ft. The steam main was a 10-in. pipe for a distance of 600 ft., then branching to two 8-in. mains to the pumps. Bypass connections at the pumps allowed any set of pumps to be operated from either 8-in. line, and connections at the foot of the borehole, where the 10-in. pipe branched, allowed either 8-in. pipe to be supplied from an old boiler plant.

It was decided that the required information could best be obtained by determining the characteristic curves of the various pumps separately and in combination. For this purpose three meters were installed on the steam lines to the pumps. A double-end contracted weir was built on the surface to measure the discharge of the pumps, and engine indicators were used to determine the indicated horsepower, mean effective pressure, length of stroke, etc.

One of the three meters was connected on the surface to the 10-in. steam line. The other two were located inside the mines, on the 8-in. lines, 1600 ft. from the pumps. Each instrument had a calorimeter and recording pressure gage connected near-by. In order to meet accurately the wide range of flow necessary for the tests, one of the meters inside was connected to two nozzle plugs, one an 8-in. and the other an 8 x 5½-in. reducer.

In order to get the meters installed it was necessary to load them in mine cars, lower them down a slope to a gangway, haul them by mule to the airway where they were to be installed and finally carry them to the points chosen for their location. There the meters were unpacked, assembled and adjusted.

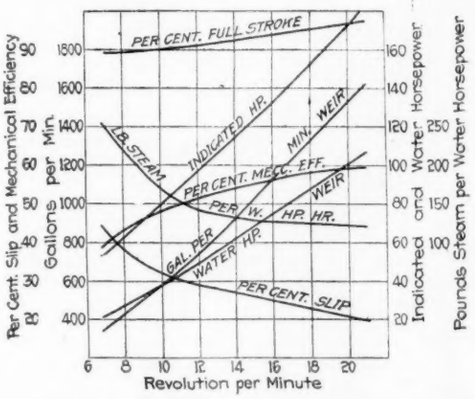


FIG. 2. CHARACTERISTIC CURVE OF DUPLEX NON-CONDENSING PUMP

Steam end, 24 x 36 in.; water end, 14 x 36 in.; head, 254 ft.; suction, 6 ft.; steam pressure, 125-134 lb.

The accompanying curves are some of those taken during this investigation. Fig. 1 was taken from tests on a duplex compound condensing pump and Fig. 2 from a test on a duplex noncondensing pump. These

*From *Coal Age*.

tests, it should be borne in mind, were taken after the pumps had been installed several years. The steam-consumption curves also include condensation losses in pipe, etc. The tests were made with the steam lines and pumps in the condition in which they were found and as ordinarily operated. They were in fairly good repair.

An analysis of the curves showed several important facts. The difference in steam consumption per water-horsepower between the compound condensing pumps and the simple noncondensing pumps was particularly noticeable. It was, of course, recognized that one type was more efficient than the other, but the large difference in economy was more easily seen by obtaining definite figures under similar operating conditions. This one item has been of much value in numerous other pumping installations, since it emphasized the facts in a way that no estimated figures have been able to do.

Another point demonstrated by the test was the lack of capacity of the pumps. The condensing pumps were rated at 4000 gal. per min. at 22 r.p.m., but they could not be safely operated above 3000 gal. per min. Their best operating capacity from a standpoint of repairs and upkeep was at 1700 to 2000 gal. per min., while their best efficiency was obtained at about 3500 to 4000 gal. per min., a rating at which they could not be operated. This not only explained the difficulty experienced in caring for floods, but also showed a wastage of about 3000 tons of coal per year due to the necessity of using the noncondensing pumps even in low-water periods.

As a result of these tests two 2500 gal. per min. electrically driven centrifugal pumps have been installed and have effected a fuel saving of about 4500 tons of coal per year. In addition, and of equal importance, is the fact that production is not now curtailed during periods of high water.

It might be interesting to note that the totals of the two inside flow meters checked within 2 per cent. of the meter on the outside 10-in. main.

After the foregoing tests had been completed a series of boiler and power-plant tests were carried out. The primary purpose of these trials was to determine power costs, boiler-plant efficiencies and, in the case of the generating plants, efficiency from the coal pile to the switchboard.

The size of the boiler plants varied from 1500 to 4000 hp. and the electric plants from 1400 to 3000 kv.-a. For these tests platform scales were used for weighing the coal. Flow meters were installed on individual boilers and on the distributing steam mains. Other equipment included feed-water flow meters, draft gages, recording pressure gages, flue-gas thermometers, Orsat analyzer, electrical instruments, etc. The plant tests were of one week duration. Individual boiler tests of 25 hours were made, checking a flow meter against the feed water measured in calibrated tanks.

Types of Boilers That Underwent Tests

The types of boilers tested were horizontal return-tubular B. & W., Stirling and Wickes. The furnaces were of the dutch-oven type, with sloping 18 per cent. air space dumping grates. Steam-jet blowers furnished forced draft in the smaller plants and engine-driven fans in the larger ones. The fuel was a mixture of No. 1 buckwheat and birdseye anthracite containing 10 per cent. moisture and 15 per cent. ash. The conditions, from a metering standpoint, were often difficult because of low velocity and pulsating flow. Nevertheless, the average error was seldom over 2 per cent, and in only one instance 10 per cent.

From the standpoint of the engineers and helpers making the test the conditions were equally trying. Boiler-room temperatures varied from 125 deg. F. down to 10 deg. Meters on steam mains, although filled with strong alcohol solution, frequently froze. Those mounted on boilers did freeze occasionally, and at times draft gage and Orsat readings were only possible by building fires on old grate bars directly under the instruments.

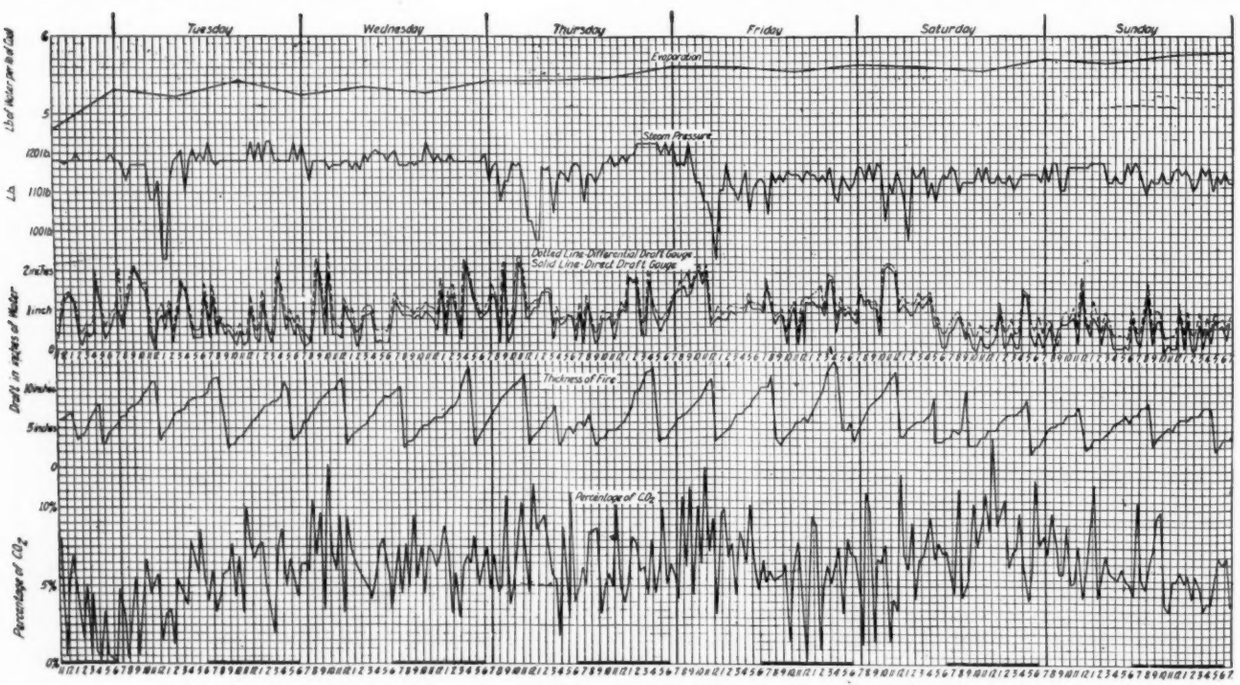


FIG. 3. EVAPORATION OF ONE BOILER FROM READINGS TAKEN IN A SIX-DAY TEST

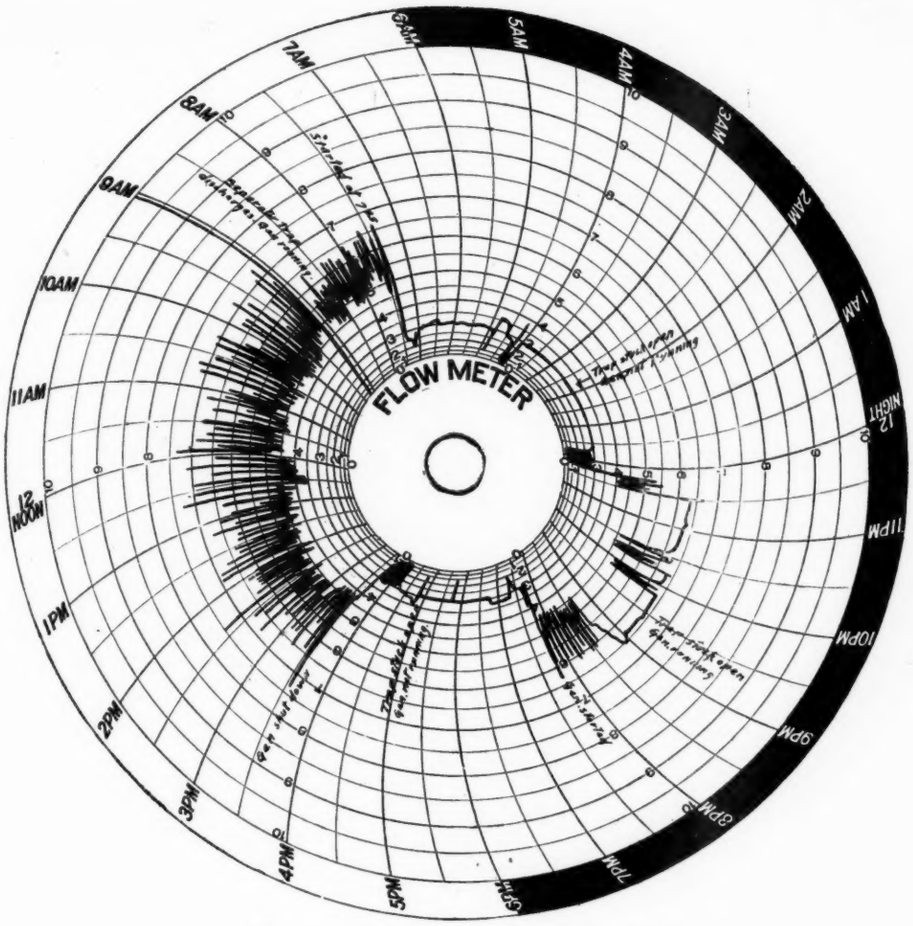


FIG. 4. A 24-HOUR FLOW-METER CHART

Power costs and distribution ratios were determined from the flow meters. The boiler units showed a general lack of capacity and a low efficiency; an average of 125 per cent. rating was the best the most modern plants could develop.

The curves shown in Fig. 3 indicate the evaporation of one boiler plotted from readings taken during a plant test of six days. The boiler was a 270-hp. Stirling. The test was made without instruction or otherwise interfering with the usual operation of the plant, the object being to obtain, as nearly as possible, the usual operating conditions.

In view of the extreme care taken to secure normal operating conditions, the rise in the evaporation curve from 4.8 lb. of water per pound of coal as fired to 5.8 at the end of the test is of interest. This curve gives an excellent illustration of the value of checking results. The increase in evaporation was due entirely to the firemen bettering their efforts as they realized they were being investigated.

Fig. 4 shows a flow-meter chart taken in one of these tests. The meter was placed on the line supplying a 300-kw. compound noncondensing Corliss engine driving an alternator. The high momentary demand lines with the engine shut down and with it running should be noted. An investigation disclosed the fact that the trap on the boiler-room header was out of order. The water from the header had been going to the engine separator and was thence discharged by the trap, causing the lines on the chart already referred to. It showed also that the separator traps frequently stuck open, allowing a steam wastage of 100,000 lb. per 24 hours. Repairing the traps remedied this trouble. In addition to disclosing a condition that might have wrecked the engines eventually had the separator traps failed to open, it was figured that the stopping of steam waste would pay for all the meters in one month's operation. After the results of these tests had been fully tabulated and analyzed, certain recommendations were made to the owners, one of which was the replacement of 15,000 sq.ft. of grate surface by new grates of smaller air space and the addition of 10 mechanical stokers. The foregoing tests, and the benefits that will accrue from them in the way of increased efficiency and fuel saving, represent a phase of engineering work in which the flow meter finds its rightful place. In many power plants there are actions going on or equipment improperly functioning which will finally make itself evident; but in many of the cases these discoveries are made only after considerable damage has been done. It is in such instances that these meters prove themselves a valuable aid.

Congress Should Unlock Water Powers

Passage of the Congressional water-power bills now in conference is earnestly to be hoped for before the close of the present session. Every engineer who is familiar with the water-power situation will agree that prompt action is needed. Water-power needs to be unlocked, to conserve fuel and to furnish profitable employment to the men released from military service and munition making. The present Congress has given more attention and study to this vital matter than any previous Congress. Its work should not be lost, especially at this critical time. Even if the bill as finally reported should be more or less of a compromise and defective in many particulars, yet if, without undue sacrifice of vital interests on either side, it opened the way for even a limited development of unused water powers, it would be well worth while as a contribution to the solution of reconstruction problems and to the conservation *and utilization* of our natural resources. — *Engineering News-Record.*

In the oil fields, a "gusher" becomes a "pumper" when its flow decreases to one or two hundred barrels a day.

The Electrical Study Course—Parallel Operation of Generators—III

Concludes the series of lessons on this subject with a study of the condition to be met in the practical operation of compound generators and the precautions to be observed when placing them in service or removing them therefrom.

THE previous lesson dealt with the methods of cutting-in and cutting-out shunt generators when several of them are operated in multiple. In the present lesson the problem as related to compound generators will be taken up in a similar manner.

In Fig. 1 are shown the connections for a compound generator corresponding to those shown for a shunt generator in the preceding lesson and which are reproduced in Fig. 2. The symbols in Fig. 1 indicate the same appliances that they do in Fig. 2, and in addition are shown the series-field winding F_s and the equalizing connection B, which is a busbar similar to M_1M_2. The operation of placing the machine in service, that is, parallelling it with another machine, is identical with that for a shunt generator, except that its voltage is adjusted to be a few volts less than that of the mains instead of equal to it. The reason for this is, that when the switch S is closed current immediately flows through the series-field winding F_s, causing the generator to be supplied with excitation additional to that of the shunt field and consequently inducing a greater generated voltage in it. The simplified diagram of Fig. 3 will make this clear. In it three generators, G_1, G_2 and G_3, are shown. G_2 and G_3 are connected to the mains M_1, M_2 and to the equalizer B, and G_1 is to be paralleled with them. Suppose the voltage across ac is made equal to that across df. This same voltage will exist across ab and there will be zero voltage across bc since there is no current through the series field F_1 and consequently no voltage drop—that is, IR drop—across it. On the other hand, there *will* be a voltage across ef equal to the drop across the series fields F_2 and F_3: that is, equal to I_tR_t, where I_t is the total load current and R_t the resistance of F_2 and F_3 in multiple. Since there is a voltage across ef, the voltage across de must be less than that across ab if the latter is equal to that across df, as assumed. We therefore have the following conditions when switches S_a, S_b and S_c—corresponding to switch S of Fig. 1—are closed: The generated voltage across ab is greater than the terminal voltage across de, consequently the generator will deliver current to the system. But in addition to this we have, as already stated, an increase in excitation due to current being caused to flow through the series field F_1. That current will flow is evident from the fact that F_1 is connected to b and c, which are connected to e and f respectively when switches S_b and S_c are closed. Since there is a voltage across ef and none across bc, it follows that current will flow through F_1 when connected to the former points, causing the increase in excitation referred to.

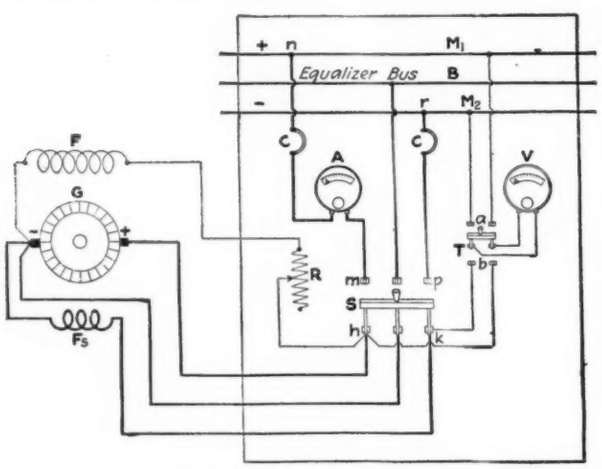


FIG. 1. DIAGRAM OF COMPOUND-WOUND GENERATOR CONNECTED TO SWITCHBOARD

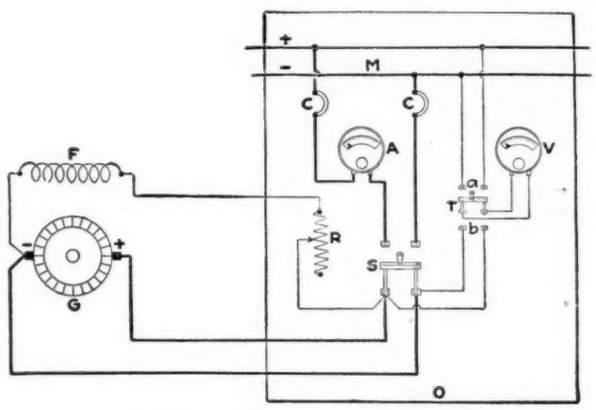


FIG. 2. DIAGRAM OF SHUNT-WOUND GENERATOR CONNECTED TO SWITCHBOARD

Just how much less than the line voltage the open-circuit voltage of the incoming generator should be is a matter of trial. Having once been determined, the operator adjusts it to that value whenever cutting-in the machine. A method of avoiding the complications indicated in the foregoing is to substitute a double-pole and a single-pole switch for the three-pole switch S of Fig. 1. Such an arrangement is shown in Fig. 4. In this case the generator is adjusted to approximately line voltage with the field rheostat and then the double-pole switch S_d is closed, thus connecting the series field F_s across M_2 and B, across which are already connected the series fields of all the other generators serving the busbars. Current consequently flows through F_s as explained in the preceding paragraph, thereby increasing the voltage of the generator. This is now adjusted to exactly the same value as the line voltage, as in the case of shunt generators, and the single-pole switch S_s is then closed, thus placing the machine in service.

Having connected a compound generator to the line, the load upon it is adjusted in the same manner as for a shunt generator; namely, by increasing its shunt-

field current by cutting resistance out of the shunt-field rheostat. When it is desired to take it out of service, the shunt-field resistance is increased until the excitation has been reduced sufficiently to cause the ammeter *A* of Fig. 1 to indicate zero current, upon which switch *S* of Fig. 1 or switches S_a and S_d of Fig. 4, as the case may be, are opened and the set shut down.

The voltmeter arrangement for shunt generators illustrated in Fig. 5 of the previous lesson and which is reproduced in Fig. 5 herein, is also used for compound machines, the points *h* and *k* of this figure corresponding to the same points in Figs. 1 and 4.

It is to be observed that the series fields of all the generators operating on the system must be connected between the same main and equalizing busbars. For example, it would not do to connect the series field of generator G_3 of Fig. 6 between M_1 and B, as shown, if the series fields of G_1 and G_2 are connected between M_2 and B. All the fields would have to be connected either one way or the other. Another point to be noted is that the ammeter for measuring the output of the generator must be connected into the side of the circuit opposite to that in which the series field is. For instance, it would be incorrect to insert the ammeter *A* of Fig. 1 in the circuit between *p* and *r* instead of between *m* and *n*, where it is shown in the diagram. In the former case the ammeter would indicate the current flowing through the series field and not that through the armature, which is the current being delivered by the machine. As was explained in the lesson in Jan. 7 issue, the total current divides up equally among all the series fields, provided they are of like resistance, irrespective of the loads carried by the machines, which depend upon the generated voltage of each.

That the ammeter will indicate the armature current when connected between *m* and *n* as in Fig. 1, but would indicate the series-field current if connected between *p* and *r* is clearly shown in Fig. 7 which is a schematic diagram of several generators connected as is the one in Fig. 1. The busbars in each are represented by the same symbols, namely M_1, M_2 and B, as also are the points *m*, *n*, *p* and *r*. The ammeters A_1 and A_2 of generators G_1 and G_2 are correctly connected, whereas ammeter A_3 of generator G_3 is incorrectly connected. Assume the resistances of all the

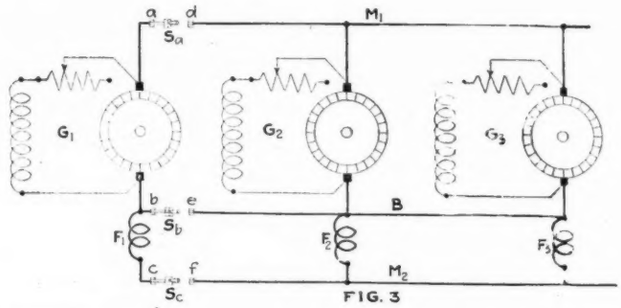


FIG. 3

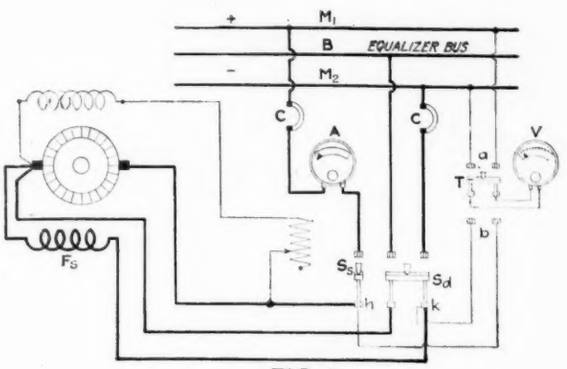


FIG. 4

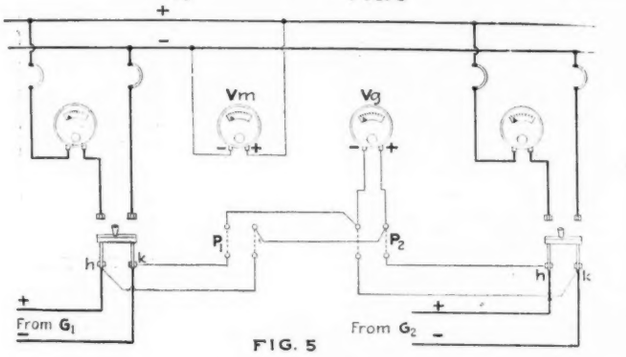


FIG. 5

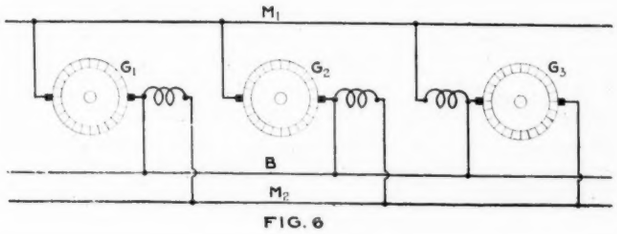


FIG. 6

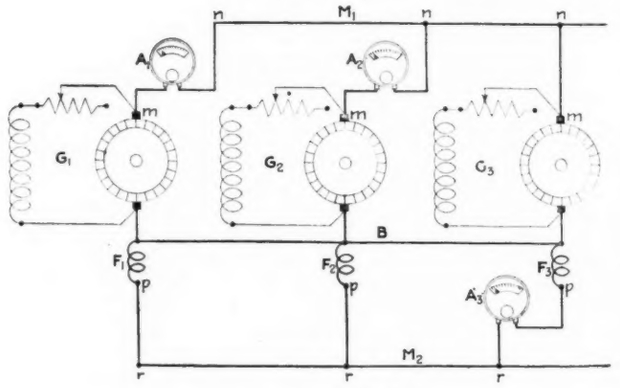


FIG. 7

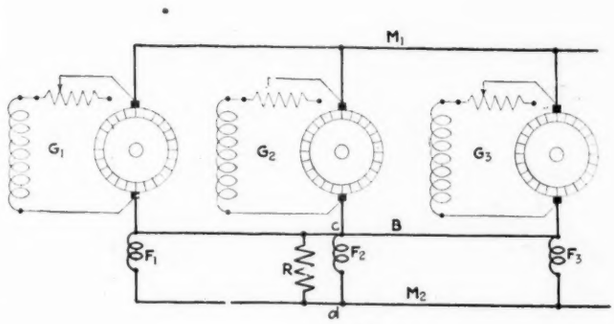


FIG. 8

FIGS. 3 TO 8. SCHEMATIC DIAGRAMS OF COMPOUND-WOUND GENERATORS OPERATING IN PARALLEL

fields F_1, F_2 and F_3 to be the same, and that G_1 is delivering 50 amperes, G_2 60 amperes, and G_3 85 amperes, making the total load 195 amperes, and the current in each series field one third of this, or 65 amperes. We would then have ammeter A_1 reading 50 amperes and ammeter A_2 reading 60 amperes, which would be the correct value of currents delivered by G_1 and G_2, but ammeter A_3 would read only 65 amperes although the current actually delivered by G_3 is 85 amperes.

Adjusting the amount of compounding of compound generators that operate in multiple introduces a problem not present when a single machine is used. The accepted manner of adjusting the compounding is to place a shunt of a low resistance and large current-carrying capacity across the series-field winding, thus diverting some of the line current from the latter and thereby reducing the series-field effect. However, when compound generators are operating in parallel the effect of placing a shunt across one of the series fields is to place a resistance in parallel with them all, since they are all connected between the same busbar and equalizer. A reference to Fig. 8 will make this clear.

Suppose a resistance R to be placed across F_3. Being connected between B and M_3, it is evident that it is in multiple not only with F_3, but also with F_1 and F_2. The consequence is that part of the load current will pass through R and the remainder will divide between F_1, F_2 and F_3 in the same ratio as before R was introduced. It is therefore impracticable to adjust the compounding by this method. It is, however, often necessary to make such adjustments in order to cause the generators to have like external characteristics, and in that case the distribution of current among the series fields may be effected by placing resistances in series with them. Thus if R of Fig. 8 were placed in series with F_1 instead of in parallel with it, the total resistance between c and d would be increased and consequently less of the total current would flow through it than before. Suppose, for instance, that the resistances of F_1 and F_2 are each 0.05 ohm, and that of F_3 is 0.04 ohm. If the total current were 130 amperes we would have 40 amperes each through F_1 and F_2, and 50 amperes through F_3. To make the current divide equally among all the fields, it would be necessary to insert a resistance $R = 0.01$ ohm in series with F_3, making the total resistance across cd equal to 0.05 ohm, to correspond to the resistances of F_1 and F_2.

In the problem of the preceding lesson it was stated that two 100-kw. 230-volt shunt generators were operated in parallel, and that the armature resistance of each was 0.01 ohm. It was required to find what the total load current would be if the generated voltage of one machine was 234 volts and that of the other 233 volts. The total current will of course be the sum of the individual currents, and the individual currents are determined by the generated voltage, terminal voltage, and armature resistance. That is, $I = \frac{E_g - E}{R}$, where I is the current, E_g the generated voltage, E the terminal voltage, and R the armature resistance. In the case of the first generator we have, $I = \frac{234 - 230}{0.01} = 400$ amperes, and for the second, $I = \frac{233 - 230}{0.01} = 300$ amperes. The total current will therefore be $400 + 300 = 700$ amperes.

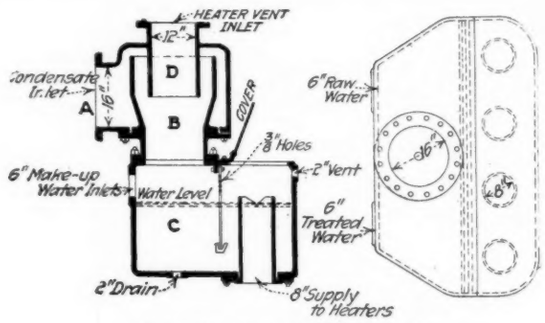
Three compound generators are operated in parallel. They are of the following capacities: 50 kw., 100 kw. and 200 kw. If the series field of the 50-kw. machine has a resistance of 0.01 ohm, what should be the resistances of the series fields of the other two?

Dividing Box with Condensing Head

BY HOWARD C. THAYER

A dividing box with condensing head, designed by the writer for use in power stations using two or more open-type feed-water heaters, is shown in the drawing. The dividing box is designed to distribute the water equally to any number of heaters. The purpose of the condensing head is to condense the large quantity of exhaust steam which at present goes to waste through the vent pipes, and at the same time it keeps the heater free of air.

In operation the hotwell pumps discharge the condensate water through the 16-in. inlet A, where it rises up and flows over into 21-in. cone B and into dividing box C. As the water falls through the cone, it forms a vacuum which draws over the steam and air in the vent pipes through the central 12-in. opening D, condensing the



DETAILS OF DIVIDING BOX

steam and allowing the air to escape through the perforated plate E and the 2-in. vents in the dividing box.

Two makeup water inlets are provided in the dividing box, permitting the treated water to be controlled by a float box at the nominal water line of the heater and the raw water to be controlled by a float box operating at a lower level. In ordinary operation only treated water is fed into the dividing box, but should the water level in the heater be pulled below the normal line at any time the raw water is admitted until the normal water line is reached.

The author of the article, "Relative Advantages of Diagonal and Horseshoe Boiler Patches," beginning at the foot of page 943 in the issue of Dec. 31, 1918, asks that a statement be published to the effect that the diagonal patches should be placed on the inside of the shell plate instead of on the outside as shown in the illustration.

The Coal Department of Denver has extended its free delivery zone. This change relieves a greater number of consumers from overhaul charges, and has at the same time reduced the overhaul rate from 50c. to 25c. per mile for those beyond the free zone.

High-Lift Centrifugal Pumps for Irrigation

By B. P. FLEMING*

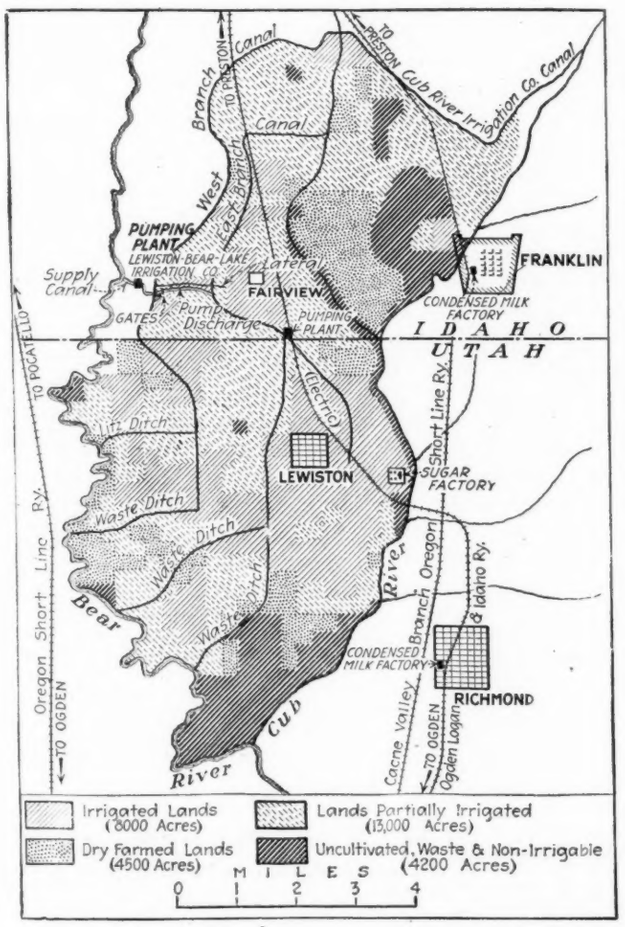
Water forced through steel manifold to reinforced-concrete conduit leading up to canal. Design features. Pump tests show over 81 per cent. efficiency under 90-ft. head.

EVERY year sees greater strides made in irrigation by pumping. This article describes a new high-lift irrigation pumping project with steel manifold and reinforced-concrete force main, put in successful operation in 1917 for supplementing the water supply of a large area known as the "Lewiston Flat" in northern Utah and southern Idaho. Power at low cost as well as intensive agriculture makes high-lift pumping feasible.

The irrigable area of the district has been estimated at about 30,000 acres, of which about 20,000 are under existing canals. For the last 40 years the water-supply has been derived from a small stream known as the Cub River, a tributary of the Bear River. The flow of the Cub varies from about 400 sec.-ft. in June to an amount not exceeding 60 sec.-ft. in July and August, during which months the sugar-beet crop is most in need of water. In normal years about 8000 acres of the Lewiston district would be fairly well supplied with water over the entire season, 8000 acres would receive only sufficient to grow grain crops or mature one crop of hay, while 4000 acres might receive no water at all.

The Bear River lies from 85 to 90 ft. below the general level of the lands in question. Its natural flow has been appropriated by agricultural and other interests along its course in Idaho and Utah, so that the only hope of the district was in securing a right to stored water. This, fortunately, was obtainable through the extensive storage developments begun by the Telluride Power Co. and completed by its successor, the Utah Power and Light Co., on the body of water known as Bear Lake, in northern Utah. This development comprised the construction of a large pumping plant of 1500 sec.-ft. capacity and control gates which, together with an artificial channel between Bear Lake and the Bear River, make it possible to divert floods into the lake and store them there or, in case of long-continued drought, permits the pumping out of the waters of the lake to a depth of 17 ft. below the normal stage and thereby augmenting the flow of the river.

*Mechanical engineer, Iowa City, Iowa, in *Engineering News-Record*.



CLASSIFIED DISTRIBUTION OF LANDS IN LEWISTON FLAT IRRIGATION PROJECT, IDAHO AND UTAH

Object of the Development

The object of this development is to insure continuity of operation of the large hydraulic power plants established on Bear River, but, incidentally, it has assisted to a certain extent in the possibility of agricultural development, by providing some stored water for the use of those who are able to secure a right to it and who can divert it below the power plants. The attractive rates for electrical power for pumping offered by the power company, together with the offer of a right to a certain amount of stored water, led to the inception of the project here described. The amount of water estimated as necessary to be supplied by pumping, to supplement gravity water, was 10,000 acre-ft. Since this amount must be supplied mainly within a period of 50 days, the capacity of the plant became fixed at 100 sec.-ft. For flexibility in operation it was decided arbitrarily to build a plant of four units of 25 sec.-ft. capacity each.

The plant was located directly west of Fairview, Idaho, at which point the Bear River approaches quite near to the present canal system of the Cub River Irrigation Co., into which the pumped water was to be discharged.

The distance through which the water would have to be carried under pressure, in the case of a plant located at the river, and the size required, seemed to indicate that only a wood-stave pipe could be considered from the standpoint of initial cost—and this fact was of the greatest weight in the decision to adopt the other type of plant.

Another factor having an important bearing on the general design of the pumping station was the type of pump to be selected, whether vertical or horizontal. This matter was not decided until after bids had been

received upon both types. It is significant of the favor with which these two types of units are regarded by the pump manufacturers themselves that, out of seven manufacturers represented, only one would offer a bid upon the vertical unit, and the others were most decidedly opposed to its use under the circumstances.

After various studies had been made, it was found that a concrete pipe was practically as cheap as a riveted steel pipe of the same internal diameter, so concrete was decided upon because of its greater permanency and lower friction loss, as well as the less difficulty in securing construction materials. The design of a reinforced-concrete manifold to receive the discharge from the four pumps proved to be so difficult that it was abandoned in favor of a riveted steel manifold. The full-discharge velocity throughout the manifold and the concrete pipe was limited to 5 ft. per second, and in the design of the manifold an attempt was made to give the easiest flow lines possible while yet maintaining a form providing a maximum of strength. The manifold has a circular section in every part, and in order to insure additional stiffness a vertical plate is riveted in the crotch of the breech-like portion. No leak of consequence was discovered in any of this riveted steel construction.

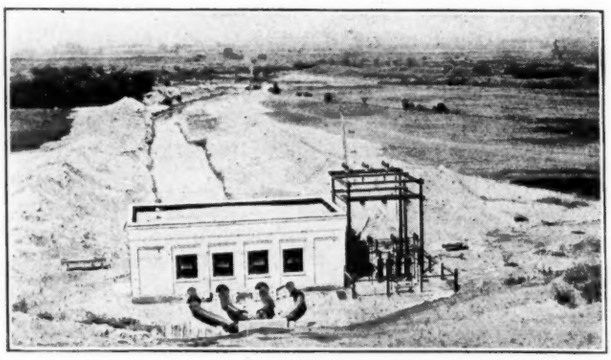
Pressure Effect from Sudden Closing of Gate Valves

Some concern was felt by the designers as to the probable pressure effect in the steel manifold and the concrete discharge pipe resulting from sudden closing of the hydraulic gate valves on the discharge side of the pumps. If, for any reason, power goes off while the pumps are in operation, the pumps almost immediately begin to run backward, and the water in the discharge pipe attains a fairly high velocity backward down the pipe. Checking this flow suddenly by the closure of the gate valve would cause water-hammer. Calculations, based on the various formulas tried, while not giving consistent results, seemed to indicate that no dangerous pressures would be developed. A small relief valve was, however, placed at the end of the steel breeching. In the operation of the plant and in the deliberate creation of conditions favorable for water-hammer at the time of testing, scarcely appreciable rises in pressures were noted.

A vacuum relief valve was also placed at the top of the concrete pipe at Sta. 14 + 17, at which point there is a break in vertical alignment where vacuum conditions may be created by the rapid letting out of water from the pipe. The free area of the air valve is about 1 per cent. of the area of the pressure pipe.

Excessive temperature changes in the concrete and steel piping were anticipated, since, although backfilling over the concrete pipe was proposed, it was not of sufficient thickness to insure against considerable daily and seasonal temperature changes, while the steel piping was completely exposed. Expansion joints in the concrete pipe were considered, but the difficulty of construction and the possibility of leakage led to the rejection of expansion joints altogether in the concrete pipe and the placing of dependence upon the longitudinal reinforcement alone to prevent the formation of transverse cracks. It was planned also to construct the pipe in cold weather, and this was successfully accomplished by late spring, before hot weather had set in. No leaks of any magnitude have so far (April, 1918) appeared in the pipe although water was turned into it for the first time early in July, 1917, when there was probably 50 deg. difference in temperature between the pipe and the water. Expansion joints were introduced in the steel piping of the manifold next to the pumphouse, and the pump side of the joint was anchored securely to piers braced against the pumphouse foundation.

To drain the sump beneath each main pump unit, there is a 3-in. motor-driven side-suction centrifugal pump, with a valve-controlled 4-in. suction pipe. For priming the main pumps and the sump pump, a motor-driven rotary vacuum pump is provided, its suction being connected to a vacuum main from which branches lead to each pump. To the priming pump, immediately above each main unit, is attached a gage-glass by which the operator can tell exactly when the unit is primed. Some difficulty was met in the initial operation of the priming pump, due to inexperience in adjusting the amount of water needed for water-sealing it. When finally adjusted, it would prime a main unit in from 5 to 7 minutes.



WATER FROM RIVER IS PUMPED THROUGH STEEL MANIFOLD AND REINFORCED-CONCRETE CONDUIT

The hydraulic gate valves are 18 in. in size and are provided with a hand operating device for use when the pumps are first started and no pressure head is available in the discharge line for their operation. This device was found by no means satisfactory, since its design requires an entire dismounting before the valves can be operated hydraulically. The control of the hydraulic valves is centralized at a point near the switchboard, so that after priming a unit and starting the motor the operator merely turns a small pilot valve which opens the main valve. A reverse motion of the pilot valve likewise closes the main valve, so that the operation is very easy and rapid. Hydraulically rather than electrically operated valves were chosen because of their greater simplicity and much smaller first cost. Their operation in this plant has been eminently satisfactory.

Each main pump unit is an 18-in. double-suction split-case centrifugal pump with bottom horizontal discharge and vertical suction connection. The impellers are of bronze, and a bronze sleeve covers the shaft from the impeller out through the stuffing-boxes. The latter are water-sealed and were provided with bronze lantern rings.

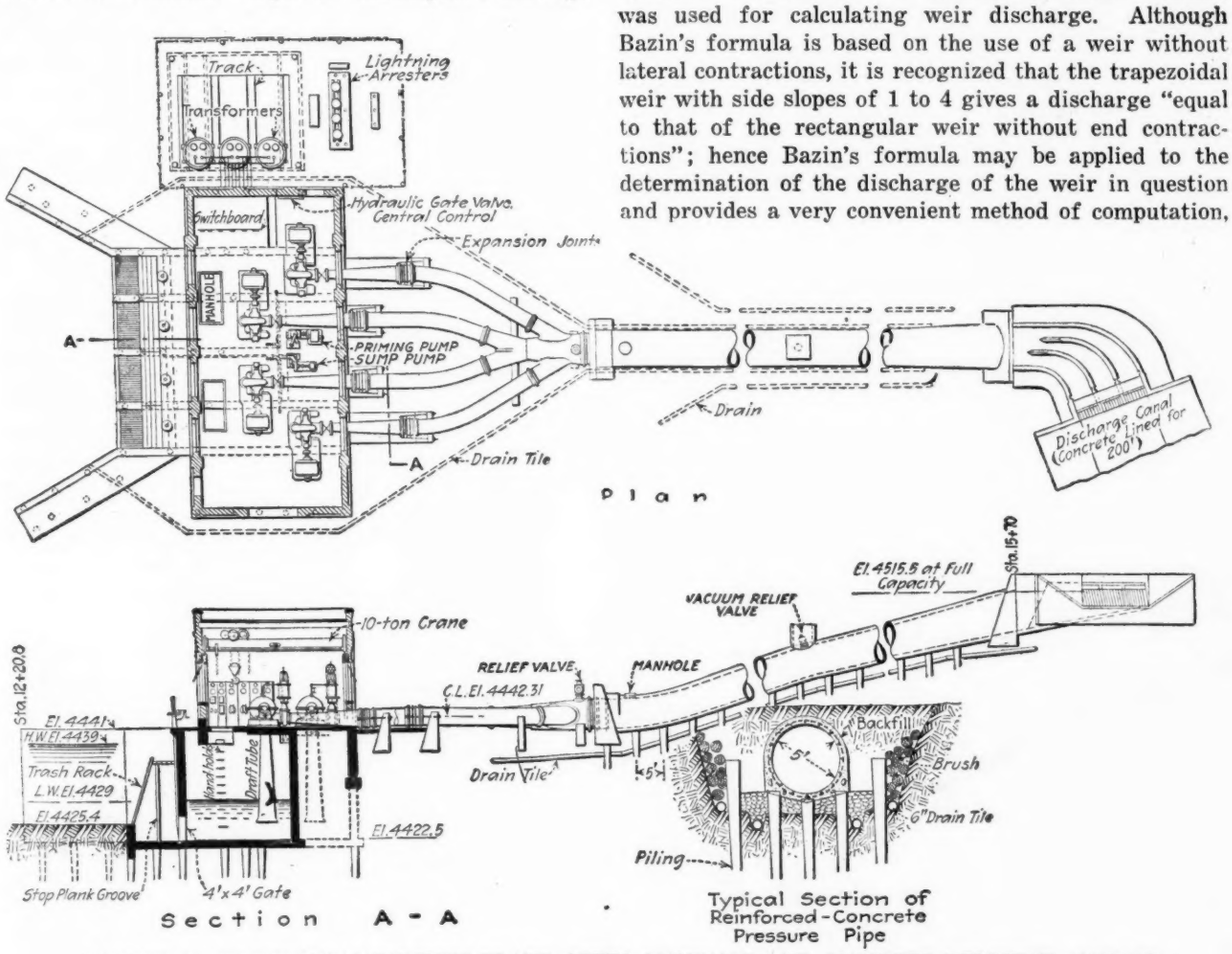
Water for sealing was taken originally from the pumps themselves, which necessitated tightening the glands when priming. It is now proposed to utilize clear water

from a spring near the station, which will give sufficient water under pressure for water seal irrespective of the operation of the pumps.

The pumps are provided with ring oiling bearings in split babbitt cases. A flexible coupling attaches the pump to a 350-hp. induction motor on the same bedplate. These motors are three-phase 60-cycle, of the squirrel-cage type, using current at 440 volts. Each motor is controlled from its own switchboard panel, the cable running in a conduit laid in the floor.

The current is transmitted to this station from the Preston substation, about six miles away, at 44,000 volts. Current is transformed into the 440 volts used at the plant by a bank of three 500-kv.-a. transformers of the outdoor, oil-filled, air-cooled type. Four 44-kv. aluminum-cell lightning arresters are provided for protection against line surges and lightning discharges, and the other equipment includes disconnecting and line switches, choke coils, expulsion fuses, etc. Serious difficulty experienced in times of electrical storms with high potential discharges on the secondary side, soon after operation was started, led to the installation of secondary arresters between the transformers and the switchboard, in addition to the more thorough grounding and transformer cases.

The contract between the pumping enterprise, or the Lewiston-Bear Lake Irrigation Co., and the Utah Power and Light Co. comprises many features intended to penalize peak-load conditions and to encourage an endeavor to economize on power consumption, although the base rate is only 1c. per kw.-hr. In the design of the plant, therefore, an effort was made to eliminate so far as possible hydraulic-energy losses in piping and sumps, and in preparing the specifications an efficiency for the pumping units themselves of 81 per cent. was demanded. This was considered a not unattainable ideal, but one of the largest pump manufacturers in the country refused to bid upon the basis of this figure, and several other manufacturers were very loath at first to offer to attain this efficiency, particularly since the contract was so worded that a certain percentage of the contract price was to be withheld pending the attainment of the guaranteed efficiency. Inasmuch as this percentage amounted to $12,000, the contract provided for complete tests of the pumps upon completion of the plant. Considerable thought was given to the matter of accurate water measurement. After rejection of other methods because of difficulty of operation or probable inaccuracies, it was decided to install a 14-ft. Cippoletti weir in the discharge canal, 200 ft. below the outlet of the discharge pipe and at the end of the concrete-lined section of the canal. The weir was constructed of 2-in. grooved and tenoned lumber with a thin steel plate for the weir crest, the weir being installed in a substantial concrete structure, with provision for removing the weir board upon completion of the tests. Heads on the weir were measured by a hook gage reading to thousandths of a foot, the zero of which was determined by an engineer's level. Bazin's formula, as tabulated in Williams and Hazen's tables, was used for calculating weir discharge. Although Bazin's formula is based on the use of a weir without lateral contractions, it is recognized that the trapezoidal weir with side slopes of 1 to 4 gives a discharge "equal to that of the rectangular weir without end contractions"; hence Bazin's formula may be applied to the determination of the discharge of the weir in question and provides a very convenient method of computation,



LAYOUT OF CENTRIFUGAL PUMPING PLANT, STEEL MANIFOLD AND CONCRETE DELIVERY CONDUIT

inasmuch as velocity of approach is taken into account in the formula and may be neglected when the weir conditions are comparable to those of Bazin, which it was the endeavor to secure in this case.

Pressure head on the pumps was determined by a calibrated Bourdon gage and suction head by a mercury manometer, both being referred to the axis of rotation of the pumps as a datum. Power input to the motors was measured at the motor terminals by an indicating polyphase wattmeter, current transformers only being used. Merely as a check, the readings of the switchboard instruments were taken during the test, but were not used in making calculations. Subsequent to the test the gages and electrical instruments were calibrated, and these calibrations were used in making the official

TABLE I. RESULTS OF CENTRIFUGAL IRRIGATION PUMP TESTS

Unit No.	Discharge Head, Ft.	Suction Head, Ft.	Total Head, Ft.	Static Lift, Ft.	Discharge, Sec.-Ft.	Water H.P.	H.P. Input	Pump Efficiency, %	Speed
1	70.1	18.2	88.3	85.35	28.36	284.5	344.6	82.5	886
1	75.8	17.7	93.5	85.26	27.51	292.0	347.6	84.0	883
1	81.5	16.75	98.25	85.05	25.95	290.0	344.4	84.2	889
2	70.1	18.1	88.2	85.34	27.69	277.5	344.4	80.6	880
2	75.3	17.5	92.8	85.20	26.82	282.8	347.8	81.3	880
2	80.5	16.9	97.4	84.90	25.76	285.0	350.0	81.4	882
3	70.1	18.3	88.4	85.23	28.52	286.2	341.6	83.8	...
3	74.8	18.1	92.9	85.24	27.81	293.6	344.6	85.2	...
3	81.0	17.4	98.4	85.38	26.09	291.9	341.6	85.4	...
4	69.9	18.6	88.5	85.55	27.72	278.3	339.6	81.9	884
4	74.8	17.9	92.7	84.91	27.22	286.3	343.5	83.4	882
4	80.3	17.2	97.5	87.79	26.32	291.4	344.0	84.7	880
1, 2, 3, 4	71.1	17.4	88.5	85.8	108.01	1086.0	1421.5	76.5	...

calculations. In calculations of pump efficiency the motor efficiency was assumed as that shown by factory test at full load, 91 per cent.

In testing (see Table I), the pumps were each run separately at three heads, the heads being varied by partly closing the hydraulic gate valves. Following the runs of the individual pumps all four were operated together to determine the action of the manifold as regards friction effect.

The most significant figures in Table I are those on pump efficiency. It will be seen that efficiencies of over 85 per cent. were attained by No. 3 unit, while all units are safely over the guaranteed efficiency of 81 per cent. at 90-ft. head. The lower efficiency of No. 2 unit is thought to be due to a small air leak in the suction pipe. This leak was not discovered until the tests had been completed. With all the pumps in operation there is noted a distinct falling off in pump

TABLE II. FRICTION LOSSES BETWEEN DISCHARGE CANAL AND FOREBAY

Unit No.	1	2	3	4	Four in Parallel
Total static lift, ft.	85.35	85.34	85.23	85.55	85.8
Discharge head, ft.	70.1	70.1	70.1	69.9	71.1
Suction head, ft.	18.2	18.1	18.3	18.6	17.4
Total head, ft.	88.3	88.2	88.4	88.5	88.5
Friction head, ft.	2.95	2.86	3.17	2.95	2.7
Discharge, sec.-ft.	28.35	27.69	28.52	27.72	108.01

efficiency which is difficult to explain, since there is no apparent reason why an efficiency determined for the four units working in parallel should not be the mean of their individual efficiencies at approximately the same conditions of head and discharge.

Table II illustrates the apparently anomalous condition of friction head decreasing as discharge increases. This is probably due entirely to the better flow conditions established in the steel manifold when all four branches are discharging than when one only is being used, so that the saving of head here more than overbalances the greater loss in the concrete pipe due to the increase of velocity when carrying 108 second-feet.

As a whole the efficiency tests of this plant illustrate the recent remarkable advance in centrifugal-pump design from the standpoint of efficiency and give reason to believe that it is not too much to expect that in the case of large units, working under reasonably high heads, 85 per cent. efficiency may be obtained where the character of the installation is such as to warrant the extra expense of a pump designed for the special conditions under which it is to operate. It is to be noted that such efficiency can be obtained only by the use of small running clearances in the impeller at the wearing ring which prevent leakage from the discharge back to suction; and the water seal preventing air leakage into the suction passage around the shaft must be perfectly air-tight. Wear is to be expected in the course of time in the wearing rings, and the glands cannot be maintained in perfect condition after a long period of use, so that to maintain the high efficiency found when the installation is new it will be necessary to renew from time to time the wearing rings and the bronze sleeves on the shaft.

The Factor of Safety

BY J. R. BELKNAP

In engineering design the factor of safety will play an important part when we have to get down to bedrock competition with the rest of the world in engineering products. For example, suppose one designer figures a machine with a factor of safety of 4 and another designs a similar machine with a factor of safety of 6. Evidently, the first has a decided advantage as to saving of material and weight and therefore price.

Some time ago a concern bought a centrifugal pumping unit which was about the lightest and cheapest thing on the market. However, it was the only thing to be had on short delivery. Realizing what kind of a machine it was, I made a special effort to get a good foundation under it, to see that the piping made no strains in the frame and that it was carefully lined up. When setting up a centrifugal pump, the coupling bolts should be left out until all suction and discharge piping is done, because no matter how well it may be lined up a pipefitter can easily pull it out of line. This plan was followed with the pump mentioned, with the result that it has never given any trouble. The efficiency is good and is maintained under a wide load range.

A learned professor once dubbed the factor of safety, "Factor of Ignorance." I would suggest "Factor of Experience."

When an oil engine is made that breaks a crankshaft, breaks another and then another, that is pretty good evidence that the crankshaft has too small a factor of safety, no matter what figures the designer might show to prove to the contrary.

A well-known motor car was designed by running the weakest parts to destruction and then increasing the factor of safety until the required length of service was obtained. The information that manufacturer has obtained by this method was costly at first, but that car has obtained a reputation for durability that has not been equaled.

EDITORIALS

The Shipping Board's Rules for Marine Machinery

IN OUR review of the year in the January seventh issue brief mention was made of the rules and regulations of the United States Shipping Board Emergency Fleet Corporation covering the building and inspection of the machinery used on board the ships made for and by the Fleet Corporation. Since then, Series One of the rules has come from the press and is now being distributed. It was necessary to formulate rules governing the allowances and tolerances for the great quantity and variety of mechanical equipment going into the enormous tonnage built and to be built by the Emergency Fleet Corporation, not only to get standardization, but to protect the investment and minimize troubles at sea. Our shipping will have enough to compete with without being burdened by the losses inevitable when ships are crippled.

When one looks casually at the little book of rules, seven by four inches, one hundred and forty-three pages, one finds it quite difficult to assess its value, to visualize all that was necessary to produce it. But if one will read over the names of the distinguished engineers who comprise the eleven committees which formulated the rules, if one will see them coming together at Philadelphia, sometimes at short notice, there agreeing upon the thousand and one differences in opinion, in shop practices, in experience—all to the end that not only should their rules and instruction produce the best and safest equipment, but permit of its production, delivery and installation in such expeditious manner that not an instant's delay would affect the delivery of the completed ship—one will get a conception of the import of the little green volume.

Now the Boiler Code was something like eleven years in the making, and it covers only some kinds of boilers. But it is an invaluable work and everybody knows it. The Emergency Fleet's rules were formulated in a matter of weeks and cover every apparatus aboard ship from propeller to boiler. Among the names in the book of rules will not be found that of the dynamic gentleman from Lowell who, as standardization engineer for the Shipping Board, directed the making of the rules. But John A. Stevens' name should be there, just as it is in the Boiler Code, which he with equal force worked so hard to formulate. No little credit is due the departmental engineers and chiefs of the Emergency Fleet Corporation who so thoroughly coöperated with Mr. Stevens and the several committeemen.

Of particular interest is the section of the rules devoted to refrigerating machinery. Probably no industry in engineering had so little standardization or more badly needed it than the refrigerating machinery industry. Yet the committee did a noteworthy work; it is complete, practicable and eminently fair. The personnel of the committee should be known: E. H. Oderman, chairman, Frick Company; James McNaught, consulting engineer, New York City; Louis Block, consulting engineer, New York City; F. M. Woodford, consulting engineer, New York City; R. A. Gulick, Brunswick Refrigerating Company, New Brunswick, N. J.; H. R. Fisher, York Manufacturing Company, York, Penn.; L. S. Morse, York Manufacturing Company. Frank Gentles and D. H. Scott were engineer and inspector respectively for the Fleet Corporation. If ever the American Society of Refrigerating Engineers wants to draft standards for the construction of its industry's machinery, it will find the Fleet Corporation's rules an invaluable guide.

The book of rules, known as Series One and open to revision as practice requires, is one of the good things in a mechanical way to come out of the war. The shop practices of the best manufacturers were thrown into the melting pot, and the most excellent and practicable poured into Series One.

The Electrical Study Course

IT IS a truism that success in any line of endeavor today, requires a better understanding of the underlying principles and a broader experience than ever before. Nowhere is this more true than in the modern power plant. The early power-plant engineer was to a large extent a mechanic backed up by strong muscles, a stout heart and a willingness to do hard work. In the small plant if he kept the steam up and the engine running when needed, and attended to the general mechanical needs out in the plant, he was a good engineer in the eyes of the owner. Consideration was rarely given to the cost of operation. In the larger plants there were one or more firemen whose highest qualification was the ability to shovel coal and keep the steam-gage hand at the required figure. How much coal they burned to accomplish this was a secondary consideration. The engineer's qualifications were judged by his ability to keep the engine running; "pounds of steam per kilowatt-hour" was a thing alien to the minds of both the plant manager and the engineer.

The day has gone when ability to shovel coal and keep the engine running is the only qualification the power-plant engineer requires. Not only must he know how to do this, but he must know how to do it most efficiently. Although he does not actually fire the boilers, he must know the most efficient way of doing it. He must be familiar with the heat value of fuels, the right amount of air for efficient combustion, temperature of flue gases and gas analysis, etc., so that he may instruct his firemen how to obtain the highest evaporation per pound of coal fired. In the engine room he must not only know how to keep the complicated multiplicity of machinery in good operating condition, but also how to produce a kilowatt-hour at the switchboard with a minimum steam consumption.

Along with the vast increases in the appurtenances in the steam end of the plant, have been added refrig-

erating equipment, ventilating and heating equipment and a vast array of electrical machinery. It is the engineer's job to see that this equipment is kept in efficient operating condition. To do this in some of the modern plants the chief engineer may have as many as one hundred and fifty men under him, or even a greater number. Thus he not only must be familiar with power-plant operation, but also must be an executive of no small ability.

Throughout this development in power-plant equipment, *Power* has endeavored to furnish those interested in power-plant operation the necessary information to assist in solving their problems. Among these problems none are larger than the electrical, for scarcely any part of a modern power plant can be considered without coming in contact with electrical devices. Among the many practical articles published in our reading columns on the installation, operation and maintenance of electrical equipment, The Electrical Study Course has appeared every other week for over two years. The purpose of this course is to give the reader who wishes a better knowledge of the fundamental principles of electricity, magnetism and electrical machinery, an opportunity to avail himself of a systematic course of study. How successful this course has been is indicated by the ever increasing demand for more of this material—a demand that has become so great that we have decided to publish lessons weekly until the course is completed. Therefore, starting this week, you will find The Electrical Study Course in each issue instead of every second week.

Light Curtailment and Accidents

THE statement that approximately twenty-five thousand persons are killed or permanently disabled, five hundred thousand seriously injured and one million slightly injured each year in this country is something that should be of serious moment to employers, even though human life has been one of the things held least dear the last four years. As pointed out in a paper, "Light Curtailment and Accidents," by R. E. Simpson, presented at the annual convention of the Illuminating Engineering Society, an abstract of which is published on page 144 of this issue, translating these figures into an economic loss, we have the appalling waste of what is equivalent to six hundred thousand employees working three hundred days per year.

That eighteen per cent. of this loss, or the services of one hundred and eight thousand men per year, is due to poor lighting should be, now that we are again turning our attention to peaceful pursuits, a very stimulating factor to our industries to use the best illumination practice available.

The inadequacy of illumination in our industries was further brought out by J. A. Sweet, in the discussion of the paper, in that probably less than five per cent. of them represent in their illumination a close approximation to the best practice, about twenty-five to forty-five per cent., although they have made a good beginning toward proper illumination, are still far short of what could be considered good practice, and the remaining fifty to sixty-six per cent. are grossly inadequate.

It has been estimated that proper illumination in our industries would result in an increase of fifteen per cent. in production. "This is equivalent to the production of an army of approximately one and a half million workers; an army that consumes neither food nor clothing nor wealth in any form; an army that produces without additional factory buildings or machinery or tools; an army that gives at least two-thirds of its wages to be divided between capital and labor."

Another economy that results from proper lighting is a decrease in spoilage due to faulty workmanship. This saving has been estimated at one hundred million dollars per year, or equivalent to the labor production of approximately one hundred thousand workers.

The indications are that competition in the future will be more keen than ever before, consequently every manufacturer will have to consider more closely means that will increase production or improve the quality or both, with little or no increase in cost. One of the most fruitful fields appears to be in furnishing the proper illumination. But this does not necessarily mean more light. Many of our industries have installed sufficient candlepower, but the way this has been applied it is far less effective than a considerably less value properly utilized. The time has long since passed when any old lamp equipped with any old shade installed in any old way constitutes good illuminating practice. Proper illumination consists in the selection of the lamp and shade best suited to each condition and maintaining it in good condition after being properly installed. The sooner this is recognized by plant managers the sooner we will begin to obtain correct illumination in our industries and eliminate some of the waste pointed out in the foregoing.

Among the stock instructions passed out in the early day to those who had to do with electric generators, etc., was: "Always keep one hand behind your back" (to avoid forming a short-circuit by a two-point contact). As electric equipment became more complex, necessitating the use of both hands, the rule had to be changed to "use both hands and your head." This new rule can be profitably applied to other work.

Cheap coal is not always cheap fuel because cheap coal usually contains a high percentage of ash, which necessitates frequent cleaning of fires, and this means frequent changes of firemen. A good fireman will not remain on a job that is practically a continuous performance of firing, leveling and cleaning out ashes. Changing firemen does not lead to economy.

It is asserted that the United States requires two hundred million piston rings annually, most of which are used for automobiles and airplanes—to say nothing of what might have happened if that $642,000,000 had gone into airplanes.

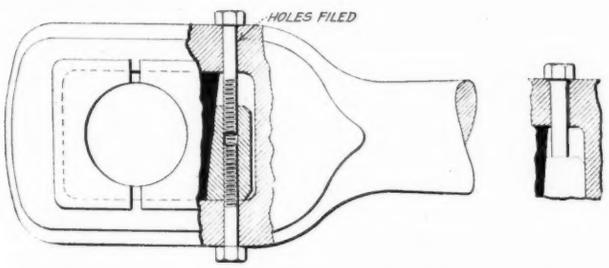
Esprit de corps is the French name for the impulse that keeps the whole engineroom force busy on Sundays, overhauling the machinery, without demanding pay for extra time.

If zoning, pooling and the avoidance of cross-hauling added to the efficiency and economy of our coal-distributing system in time of stress, why this haste to abandon them?

CORRESPONDENCE

Why Do Wedge Bolts Break?

A subject worthy of discussion in *Power* is, Why do wedge-adjusting bolts break? I have in two cases found that the wedge did not butt the rod end properly and this caused a partial shearing effect. The first case developed in a very slow-running four-valve engine when the steam pressure was increased from 65 to 100 pounds.



WEDGE HELD AWAY FROM ROD BY THE BOLTS

The illustration will explain the trouble. The draw bolts were a very good fit in the rod and when strain was applied the wedge stood away from the rod about sixteen-thousandths of an inch. Of course the pressure forced the wedge back where it belonged, but this put a strain on the bolts and sometimes the bottom bolt would break and again the top bolt would break. It was somewhat of a job to file the holes in the rod back so that the wedge would seat properly, but it was worth the candle.

The second case was that of the top bolt breaking under the head. In this case a condenser had been connected to the engine, as the steam pressure could not be raised and the engine was lagging. The second week after the new condenser was placed in operation, the top bolt broke under the head. A new bolt was put in, after about three hours' work and this bolt broke in the same place in less than one week. Our old machinist suggested that the hole in the rod be countersunk a little and a bolt made with a fillet under the head, as shown in the smaller section. This cured the trouble.

Without doubt poorly fitted boxes that play in all directions may cause the wedge bolts to break, and running a box so loose that it pounds will produce the same trouble. I never had a large wedge bolt (1¼ or 1½) break, though I have had several in operation. The ones referred to were ⅝- and ¾-in. bolts.

New York City. C. W. PETERS.

Control of Forced Draft

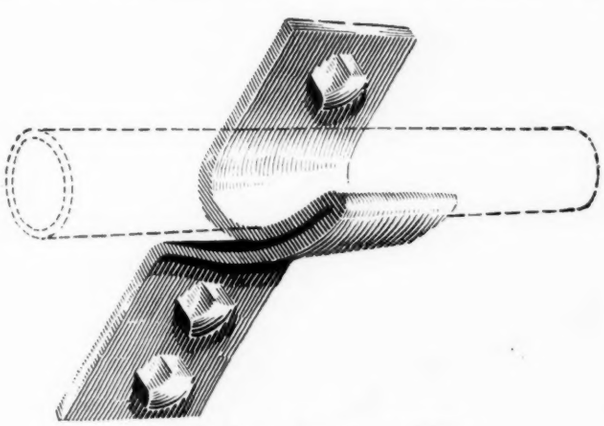
J. T. Sharp, Jr., described in the issue of Dec. 24, 1918, page 929, an ingenious automatic control for forced draft when using undergrate blowers. It has been my experience that the best method of operating turbo blowers is to carry a sufficient air pressure under the grate to maintain a pressure just a shade under that required to overcome the friction resistance of the fuel bed. This will give a slight vacuum or draft over the fuel bed, which will measure from 0.05 to 0.10 inch of water. Adjust the blower to give a pressure of from 0.40 to 0.45 in. of water and allow the natural draft to overcome the remaining part of the fuel-bed resistance. This is a balanced draft condition which will overcome back flashing through the firing doors. Minimum draft above the fire will prevent, to a large extent, the loss due to drawing in cold air through the open firing doors and also will cut down air infiltration through the setting. It is wise in any case to install draft gages, at least one in each ashpit and one in the combustion chamber, so that conditions may be checked at all times.

It may be possible that the back flashing when the fire-doors are opened is due to noncombustion of the volatile matter in the slack or dust. If the fire-doors are left ajar for a few minutes after firing, it is likely that this trouble will disappear, as the air drawing in over the fire takes care of these unburned gases. The Bureau of Mines recommends equal amounts of air over and under the grates for the average semi-bituminous coal. Leaving the fire-door ajar immediately after firing will usually furnish the extra quantity of air required for complete combustion. R. B. CLAPP.

Pittsburgh, Penn.

A Simple Pipe Bracket

The article on "Various Types of Pipe Hangers" appearing on pages 770 and 771 in the issue of Nov. 26, 1918, brings to mind the bracket shown in the illustration. It is made of a single piece of strap iron, is very easily fashioned and will carry pipes up to 6 in. in diameter. There appears to be no reason why it could not be used for larger sizes, but I have not seen it applied to such. WILLIAM H. WATSON.



A ONE-PIECE PIPE BRACKET

Morristown, Penn.

Column Blowoff Valve Leaks

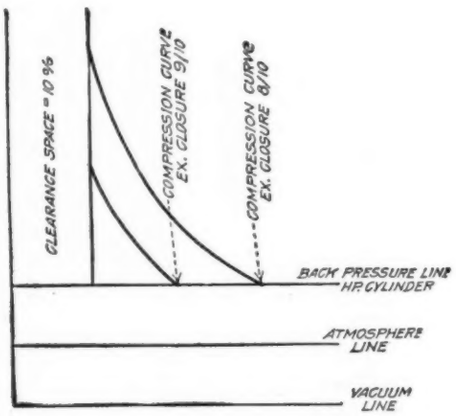
We had considerable trouble with the blowoff valve on the bottom of the gage-glass dripping constantly. We frequently renewed the valves, but they would not stay tight long. I extended the pipe from the bottom of the gage-glass and put the blowoff valve on the lower end of the pipe. This seems to protect the valve to some extent and prevents leakage. In that way the blowoff valve lasts considerably longer.

This is a simple suggestion, but it may help someone that is having similar trouble. R. A. WILLIAMS

Manassas, Va.

Unsymmetrical Indicator Diagrams

Referring again, if I may, to the subject of unsymmetrical indicator diagrams in answer to Mr. Hughes in the issue of Jan. 7, 1919, page 29, I submit the theoretical compression curves for a case where the compression begins at nine-tenths stroke and the other where it begins at eight-tenths stroke, the clearance space being 10 per cent., or equal to one-tenth of the


CLEARANCE SPACE = 10 %
COMPRESSION CURVE EX. CLOSURE 9/10
COMPRESSION CURVE EX. CLOSURE 8/10
BACK PRESSURE LINE H.P. CYLINDER
ATMOSPHERE LINE
VACUUM LINE

COMPRESSION CURVES FROM TWO DIFFERENT POINTS

volume of the piston displacement. The compression pressure from nine-tenths stroke is, of course, double because the steam entrapped is compressed into one-half the space. This may be taken as the original condition at both ends of the cylinder—referring to my letter in the issue of Dec. 10, 1918, page 856. If all the compression is thrown to one end of the cylinder, then the exhaust valve will close at eight-tenths stroke and the compression curve would correspond to the upper curve. The final pressure would be three times the original, because three volumes have been compressed into one. The measurement by planimeter of the large area is found to be about 50 per cent. greater than the smaller area doubled, for the two ends.

It is obvious since the average pressure shown by the upper curve is greater and the distance traveled by the piston against compression in both cases is the same, whether all done at one end or divided, that the total resistance or compression effort is greater when all at one end.

The main point, however, is the broad principle that an indicator diagram from a given engine operating perhaps under unusual conditions "does not have to look like the picture in the book" to be the best one for that engine to produce. The final test is the operation or running of the engine—like the proverbial test of the pudding. My mode of procedure is to set valves to conform to the conventional as nearly as possible, and then modify the adjustment in such a way as to get the best operation under the given or average conditions. The final test on erecting a new engine or adjusting one should always be to slack back on the adjustment of the crank and crosshead pins and run the engine from no load to full load. If it does not operate reasonably quietly, it is not right either in design or adjustment. If the design is wrong for the operating conditions, as cited, the operation may in many cases be improved by so adjusting the valves as to counteract the structural defect. This in no way deprecates the use of the indicator because it is all the more necessary to use one in adjusting the engine in the same way later. J. LEWIS.

New York City.

Requirements of a Diesel Operator

In his letter appearing in *Power* of Jan. 7, Mr. Cooke falls into the all-too-common error of insisting that intelligence and not skill is the main requirement of a Diesel operator. I do not believe any manufacturer of steam engines would venture to suggest that the operating engineer need not be skilled. The corner grocer is intelligent, in the accepted meaning of this word; still, Mr. Cooke would probably insist that the operator of one of his engines be not only well-informed on current matters, as is the grocer, but also versed in the particulars of oil engines. If a man is well-versed in any line, it is usual to term him skillful in that line.

Mr. Cooke perhaps intends to convey the idea that there is no special mystery about the functioning of a Diesel engine and that any good steam engineer can, after some experience, successfully cope with all operating difficulties that arise. If this is the idea he intended to convey, he is undoubtedly correct in his argument. Any man who is capable of meeting the many perplexing problems that arise in a modern steam plant possesses enough intelligence and, in all probability, enough mechanical skill to operate any oil engine after some training.

The one great obstacle that the steam engineer must overcome is his natural aversion to any form of internal-combustion engine. This feeling is the result of his belief that the peculiarities of the oil engine are baffling. The steam operator is accustomed to having the causes of practically all ordinary plant defects perfectly transparent. If the problem is baffling, the steam plant usually continues to function, even though at decreased power or increased cost. On the other hand, the Diesel engine, as the editor expressed it, must operate economically or not at all.

The operator is seldom given time to investigate the reason for the operating defect. He must be able to decide immediately on the proper procedure to follow in correcting the fault. For instance, if the engine slows down, one of a score of things may be the cause. The fuel supply may be gone; the fuel line clogged; the fuel oil mixed with water; the fuel-pump valves leaking; the fuel valve wedged open; the injection-air pressure too low, due to one of a dozen probable reasons; the piston rings broken, destroying the compression; the

lubrication of the cylinder defective; the cooling-water supply inadequate to cool the cylinder thoroughly; or a number of other things not enumerated. The majority of these defects may exist without the fact being at once apparent. To the steam engineer this condition is baffling and he usually ends up by unjustly condemning the engine.

The writer has met many steam engineers who have tried to operate oil engines, and in most cases they regard the oil engine as a sort of magic worker. They see its hands are open, but are positive it will pull a white rabbit or at least some kind of jinx out of its overalls pocket. If the steam operator will put aside his personal objections, there is no reason why, with some months of training, he should not qualify as a Diesel operator.

Mr. Cooke may have intended to convey this idea of the adaptabilty of the steam engineer to Diesel operation. However, his mention of the Ford engine to prove that skilled attention is not essential would seem to indicate a belief that any man of intelligence, but without mechanical skill, can be immediately transformed into a Diesel operator. Let us consider the Ford. This engine rates about 20 hp., but with the usual road conditions a Ford owner runs his machine at around 7 hp. output. The engine is then running at some 30 per cent. of its rating, and the wear is correspondingly low. Furthermore, it is the exception rather than the rule for a Ford to run more than two or three hours without a stop. In fact, most owners seldom make runs extending over an hour's time. Even though the load factor is under 50 per cent. and the period of operation less than 10 per cent., the Ford engine will wear out. Thirty thousand miles is much higher than the average Ford engine covers before it is ready for the junk pile or second-hand dealer. At 20 miles per hour this represents 1500 hours of operation. Would Mr. Cooke be satisfied with a 1500-hour life for the McIntosh & Seymour Diesel? To the contrary, it has been stated by the McIntosh & Seymour Corporation that their engine needs no important adjustment of bearings, etc., inside of 10,000 hours of service. No reasonable person will deny that a considerable part of the rapid depreciation of the automobile is due to the lack of skill on the part of automobile mechanics.

The Diesel engine does not enjoy the popularity in America that is due it. This can, in a large measure, be attributed to manufacturers' statements of the lack of skilled attention required. The purchaser invests and, with the glowing statements of the builder in mind, forthwith employs an attendant who could not run a sawmill steam engine, but who is undoubtedly intelligent—at least, he votes.

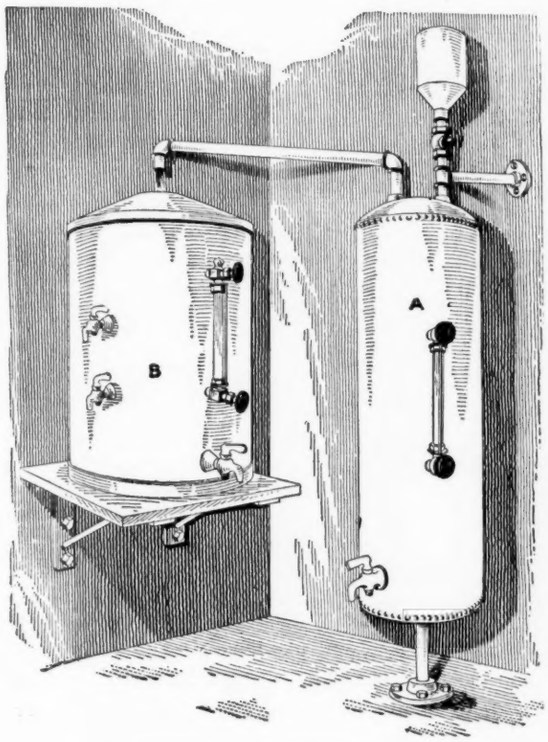
The writer has never been able to understand why the Diesel builder lays so much stress on the claim that skilled help is not necessary. Even with high-priced labor the Diesel is economical. In a Texas Diesel plant of 1500-hp. capacity a high-priced chief, who is a machinist, is employed. While the watch engineers' pay is above the normal rate, still the total cost per kilowatt output, including a 15 per cent. fixed charge on plant cost, is under one cent. This is lower than the cost at a Texas steam turbine plant of over 10,000-kw. capacity using 8-cent gas as fuel and with only a 12 per cent. fixed charge.

The successful Diesel operator must be, above all, a machinist. If the chief engineer of a plant does not possess this requisite, then a machinist must be employed, or the plant faces rapid deterioration. The Diesel is the most economical prime mover in existence at present and is altogether a most satisfactory unit. The writer has operated several makes and investigated a number of plants, and without exception the successful plant has a machinist in its organization.

Philadelphia, Penn. E. E. SNOW.

An Easily Made Oil Filter

A short time ago, while visiting a neighboring power plant, I saw an oil filter that is a little out of the ordinary and that can be easily made. There were only two 50-kw. units in the plant, each of which had a gravity oiling system, with a small tank placed above



OIL-WASHING TANK RELIEVES FILTERS

the highest bearings. All waste oil was drained off into a bucket and emptied by hand into the filter, made as shown in the illustration.

Tank *A* was a 30-gallon range boiler and *B* is a small oil filter. Tank *A* is filled about half full of water. The used oil is poured into the funnel at the top, which holds about three gallons, and flows slowly down the pipe extending inside of the tank to the bottom similar to the cold-water pipe in a range boiler. The cock is partly closed to regulate the flow. The oil then passes up through the water to the overflow pipe at the top to the tank, during which time the water washes out the foreign matter and cleanses the oil. The drain-cock at the bottom of tank *A* is opened at intervals and the sediment flushed off and clean water added at the top. It is necessary to clean the second filter only at long intervals and clean oil is assured

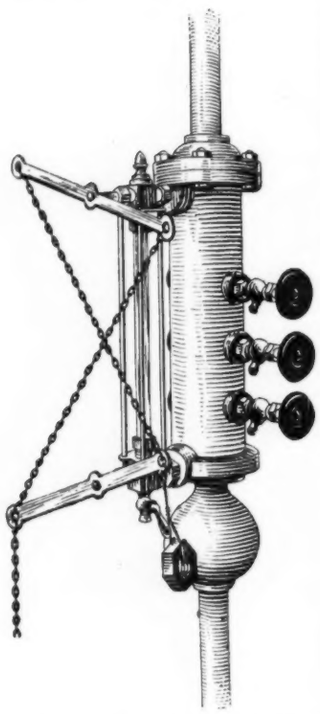
with little attention. It could be improved by means of pumps to handle the oil automatically, but the amount of oil used is so small that it can be done by hand in a few minutes. J. C. HAWKINS.

Hyattsville, Md.

Boiler Tubes Were Burned

I had occasion recently to accompany a boiler inspector to a plant containing a 350-hp. water-tube two-drum curved-tube-type boiler, and what we found there was interesting.

The first nest of four rows of tubes were almost without exception burned away, beginning a few inches above the ashes that lay on the lower drum and upward for four or five feet. This, of course, caused the baffle walls to collapse and expose the tubes of the second pass, and most of these tubes were also burned out or twisted out of place. All drums were found intact. The lower drum had a heavy covering of ashes, which no doubt saved it from being burned, and the upper one was quite a distance from the fire. Inspection was continued to the water column, where a dangerously rigged-up affair was found. The gage glass valves were originally operated by arms and chains, from the floor, but the chain from the opening arm of the water valve was missing and instead there was a light metal weight hung on it, not heavy enough to overcome the friction of the packing. The other, or closing, arm had a chain hanging to within reaching distance of the floor.



CHAIN CONNECTION AS FOUND

The chain connections between the steam and water valves were crossed as shown in the illustration, and obviously, when the floor chain was pulled the water was shut off and the steam connection opened, or if the weights happened to open the water connection, the steam connection was closed. The water connection was found closed and was probably in that position when the "burnup" occurred. J. M. REEVES.

Mercedes, Tex.

Chemical and Physical Control of Boiler Operation

As might be expected from anything written by Mr. Uehling, the article on "The Chemical and Physical Control of Boiler Operation," printed in your issue of Jan. 7, is a valuable contribution to the literature on coal conservation. However, we think that Mr. Uehling has devoted himself to chemical and physical control so long that he unconsciously overlooks or rather slights mechanical control.

For example, he states regarding weighing of coal to boiler for comparison of readings of hot water or steam-flow meters: "The results cannot be calculated oftener than once a day and generally once a week is considered sufficient for a control over the operation of a boiler plant." Automatic boiler scales give a continuous record of the coal delivered to each individual boiler and hourly comparisons can be made, if desirable, although comparisons of consumption on different shifts are more customary. Mr. Uehling is evidently comparing obsolescent hand-weighing methods with CO_2 recorders, etc.

Again, he says: "The coal weigher cannot discriminate between coal, ash and moisture and since these constituents are never constant and frequently vary 5 per cent. or more in successive shipments, and since the heat value of the fuel depends on its purity, the calculated results will be that much in error." This is true, but he ignores the fact that the greater accuracy of automatic coal scales (one-half of one per cent.) over CO_2 recorders, draft gages, pyrometers, etc., probably more than compensates for the variables mentioned.

He states further: "The mechanical control has another and even more serious shortcoming in that it gives absolutely no clue as to why the plant as a whole is operating more or less wastefully." He ignores the fact that CO_2 recorders, pyrometers or draft gages by no means cover the entire field of boiler efficiency. For example, the boiler may be scaly or the quality of the coal may be poor, without their indicating same. A comparison of coal consumed with water evaporated or steam pressure obtained indicates if anything is wrong.

When Mr. Uehling in contrasting the two methods of control—mechanical and physical and chemical—says that "either method is better than no control at all, and neither method is by itself adequate to produce maximum economic results," he states the full truth. There is room for both mechanical and chemical and physical control of boiler-room operation and nothing short of both is control. F. ODONE,

Passaic, N. J. Richardson Scale Co.

Current in the Center Conductor of a Two-Phase Three-Wire System

On page 31 of the Jan. 7 issue of *Power*, "Inquiries of General Interest," answering the question by W. D. T. in regard to "Relations of Currents in A. C. Systems," I notice what appears to be a typographical error.

In the section of the answer referring to currents in a balanced two-phase three-wire system the current in the two outside wires is given as $I_c = I_b$, I_b being current per phase in an equivalent two-phase four-wire system. The current in the common wire is given as $I_c = \sqrt{2 I_b}$; this expression should read $I_c = 1.\overline{2} I_b$. That is, I_b should not be under the radical, but should be multiplied by $\sqrt{2}$ (1.414). In other words, the current in the center leg of a balanced two-phase three-wire system is equal to the current, in amperes, in one of the outside legs times the square root of two.

Newark, N. J. W. E. CLEMSON.

INQUIRIES OF GENERAL INTEREST

Depolarized Belts—Pumps, driven through depolarized belts, for transmitting gasoline, have been ordered for one of our plants. How is depolarization of belts accomplished? S. R.

Belts running at high speeds in dry places take on a high static electrical charge. The sparks caused by the discharge from such belts become very dangerous where gasoline fumes or other highly explosive fumes are present. The usual method of overcoming static is to place one or more metal combs in close proximity to the belt and connect them to ground. Pieces of small chain or wire may be used for the same purpose. Driving these pumps direct would seem to be a much better practice, as this would eliminate any trouble that might arise from the use of a belt.

Varying Speed of a Compound Motor—Can the speed of a compound-wound motor be adjusted by the use of a variable resistance connected in series with the shunt-field winding as in a shunt-wound motor? W. N. C.

The speed of a compound motor cannot be adjusted by introducing a variable resistance in the shunt-field winding, and operate as a compound machine, as with a shunt motor. This is due to the ampere-turns of the series winding becoming more effective as the ampere-turns of the shunt winding is reduced. Where a drive requires a compound motor during the starting period and shunt-field control after, the series winding is cut out of circuit before introducing resistance into the shunt-field circuit. Such conditions are found in elevator and printing-press drives, etc.

Charge for Steam with Increased Price of Coal—The cost of operating a boiler plant to supply ourselves and a tenant with steam for heating buildings during last winter was $18,674.55 for coal at $9.50 per ton and $3948.11 for wages, supplies, repairs, water and removal of ashes. What should the tenant be charged per 1000 lb. of steam in a new contract based on $9.50 per ton for coal so the price will be equivalent to that charged by a former contract of $0.50 per 1000 lb. when coal was $4.25 per ton? S. T.

In addition to the operating expenses mentioned, an estimate should include overhead charges such as ground rent, interest on investment in boiler and equipment, allowance for depreciation amounting to about 7 per cent. per annum, taxes, insurance, cost of supervision and reasonable profit, and the total charges applicable to each period should be considered. But if such data are not available, and it is conceded that an operating expense of $3948.11 and an overhead of $3000 are applicable to both periods under consideration, then during the last season the total cost may be considered to be $18,674.55 + $3948.11 + $3000 = $25,622.66 and the proportion chargeable to coal was 18,674.55 × 100 ÷ 25,622.66 = 72.8 per cent. As this is based on coal costing $9.50 per ton with other expenses the same as during the first period, a charge of $0.50 per 1000 lb. of steam based on coal costing $4.25 per ton would be at a loss of one-half of 72.8 per cent. or 36.4 per cent., and the rate based on coal costing $9.50 per ton should be $0.50 ÷ (100 − 36.4) = $78\frac{6}{10}$ cents per 1000 lb. of steam.

Improvement of Draft by Cleaning Chimney Connection—A boiler fireman was informed by his superior that no improvement of draft was to be obtained by cleaning out the smoke connections to the chimney which had become filled about one-third full of soot. What is the explanation of this, if true? B. F. G.

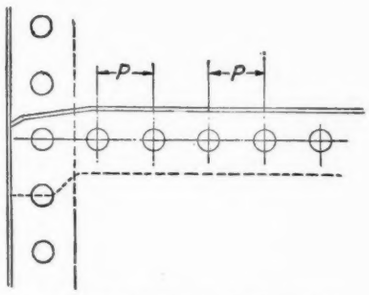
For a given force of draft and given size of chimney flue, the volume of furnace gases that can be carried off depends on the least cross-sectional area of smoke-pipe connection and the smoothness of the passages for the gases from the boiler to the chimney. Sharp corners and short bends cause swirls and eddies that give rise to soot deposits which smooth out the channel and usually result in so much higher average velocity that there is a greater volume of gases discharged with the reduced but modified cross-sectional area. Generally speaking, removal of the soot deposits will not improve the volume of draft, unless it results in enlarging the smallest cross-sectional area for passage of the furnace gases. However, no serious error is made by removal of a greater quantity of soot for, in very short time, deposits again form in best arrangement for maximum draft.

Objections to Excessive Blowdown of Pop Valve—Why is it more objectionable to have a boiler safety valve blowdown 10 lb. than 4 lb. below the pressure for which the valve is set to pop? R. W.

The greater the blowdown the lower must be the available working pressure below the safe working pressure for the boiler. In addition to this disadvantage in operation, the broader the variation of pressure on the boiler the greater the injury to the joints and material in the nature of a racking effect. The amount of blowdown allowable should be considered with reference to the pop pressure. It is considered good practice for the valve to be adjusted to close after blowing down not more than 4 lb. on boilers carrying 100 lb. per sq.in. gage; 6 lb. on boilers carrying 100 to 200 lb.; and not more than 8 lb. on boilers carrying over 200 lb. per sq.in. gage.

Safe Working Pressure for Air Tank—What is the safe working pressure for an air tank 42 in. diameter, made of $\frac{1}{4}$-in. steel of 55,000 lb. T. S. with single-riveted lap seams, diameter of rivet holes and rivets after driving $1\frac{1}{8}$ in. and pitch of rivets $1\frac{3}{4}$ in.? G. N. H.

For thickness of plate $\frac{1}{4}$ in. = 0.25 in.; pitch of rivets $1\frac{3}{4}$ in. = 1.75 in.; diameter of rivet holes and rivets after driving, $1\frac{1}{8}$ in. = 0.6875 in., giving cross-sectional area of rivet = 0.6875 × 0.6875 × 0.7854 = 0.3712 sq.in.; and allowing a shearing strength of rivets = 44,000 lb. per sq.in. of cross-section and 95,000 lb. crushing strength of plate, for a length of the shell equal to the pitch P in the sketch there would be:



SINGLE-RIVETED LAP JOINT

(A) Strength of solid plate = 1.75 × 0.25 × 55,000 = 24,062 lb.

(B) Strength of plate between rivet holes = (1.75 − 0.6875) 0.25 × 55,000 = 14,609 lb.

(C) Shearing strength of one rivet in single shear = 1 × 44,000 × 0.3712 = 16,332 lb.

(D) Crushing strength in front of one rivet = 0.6875 × 0.25 × 95,000 = 16,328 lb.

The strength of the longitudinal joint would depend on consideration (B) and the efficiency of joint would be $\frac{(B)}{(A)} = \frac{14,609}{24,062} = 0.607$, or 60.7 per cent.; and with a factor of safety of 5 the maximum safe working pressure would be $\frac{55,000 \times 0.25 \times 0.607}{(42 \div 2)5} = 79.4$ lb. per square inch.

Light Curtailment and Accidents*

By R. E. SIMPSON

THE significance of accident prevention will be readily appreciated if we consider the effect of accidents in terms of time lost. From the published statistics of a number of states, together with conservative estimates for the remainder, we find that approximately 25,000 persons are killed or permanently disabled, 500,000 seriously injured and 1,000,000 slightly injured each year. Translating these figures by means of the accident severity rates, we have a total of 180,000,000 days of lost time. This is equivalent to the loss of the services of 600,000 men for a full year of 300 working days. This economic loss is distributed over the entire country during a period of one year, and for that reason its effects are not so keenly felt or its importance recognized.

It is apparent we have here an important factor touching on the supply of labor, and anything that can be done to curtail this economic loss is worthy of careful consideration. There is a certain percentage of unavoidable accidents; that is, man's prevision is unable to cope with unknown factors, and this is especially true of pioneer work. The best that can done is to profit by experience, and endeavor to prevent the knowledge and experience thus gained from lagging behind practice. A large percentage of accidents may be classed as avoidable in the sense that the application of mechanical safeguards and the observance of safety rules will prevent them. Anything in the form of a practicable guard, of safety education, or of safety regulations that will protect the worker from injury should be welcomed by the plant manager today. Past investigations have indicated various influences on the causation of accidents, and prominent among these is industrial lighting.

Percentage of Accidents Due to Faulty Illumination

A survey of 91,000 accidents from the records of The Travelers Insurance Co. for the year 1910 showed that 23.8 per cent. were due to improper or inadequate illumination. Bearing in mind the progress in the art of illumination during the past eight years, it is hardly possible that this percentage prevails today. New factories are lighted by up-to-date equipment, while many old plants have had their lighting systems brought into conformity with modern practice. These are steps in the right direction and are bound to be reflected in the accident rate. Offsetting this, to a certain extent, is the practice of many plant managers of substituting high-efficiency lamps, both gas and electric, for low-efficiency lamps, without providing adequate reflector protection. Notwithstanding the vast amount of expert advice that has appeared in the technical journals devoted to specific industries, there are literally thousands of plants that have not profited by this advice. The directing personnel of these plants, from managers to subforemen, do not seem to appreciate the difference between light and illumination, between a reflector and a wire guard.

There is some foundation, however, for assuming that 18 per cent. of our industrial accidents are due to defects in the lighting installation. On that basis the services of 108,000 men for one year are lost annually, because the illumination provided is not adequate for the safety of the workers. That this condition should exist year after year is all the more reprehensible because of the fact that the remedy is so easily applied and has beneficial results in many ways other than in the element of safety involved. Accidents caused by carelessness, inattention or ignorance can be eliminated only by a long-continued, painstaking educational campaign often involving a change in long-established habits. The elimination of accidents due to inadequate or improper lighting is simply a matter of purchasing approved equipment and installing it under competent direction. In fact, it seems proper to include illumination in the list of mechanical safeguards, for the reason that the lamps and reflectors provide the guard—illumination—to point out the hazard, just as effectively as a railing points out the danger of and provides protection against the hazard of a revolving flywheel. The sum involved is insignificant when compared with the accident claims, or the lost profit on the product of the labor, or the value of the product itself.

Anyone who makes an extended survey of the lighting conditions of our industries will inevitably be impressed by the much larger percentage of *improper* installations when compared with the *inadequate* installations. This is due primarily to the praiseworthy, but none the less ill-advised, attempts to better the plant illumination on the basis solely of providing a greater candlepower output. The questions of distribution, diffusion and absence of glare are either not fully appreciated or are entirely unknown, and therefore do not receive proper consideration.

Coal Saving by Curtailment of Industrial Lighting Negligible

The saving in coal by curtailment of industrial lighting is negligible when compared with the ultimate economic loss. For example, if the full year's labor of the 108,000 men that is lost annually, due to poor illumination, could be saved and applied to coal mining, 130,000,000 more tons of coal could be produced. To provide ample illumination for the safety of all these workers, ten hours a day for a full year, would require less than 10,000 tons of coal. We may convert this fact into a more detailed and concrete form by saying that a 25-watt lamp burning ten hours a day will provide adequate illumination on a stairway for one year by the use of one-eighth of a ton of coal. By dispensing with the lamp one-eighth of a ton of coal will be saved, but if during the year one accident occurs involving the loss of only one day's time the economic loss from a coal-producing standpoint would be sufficient to operate the lamp 32 years.

This brings us up to the point of considering the effect of diminished lighting at places where such reduction is almost invariably found. Stairways, elevated gangways, passageways and storage spaces are generally inadequately lighted and are the first to suffer from a policy of light curtailment. The hazards associated with these poorly lighted sections of our industrial plants have been portrayed many times. Confirmation of these hazards has been given by the report of the British government survey of industrial accidents showing that 40 per cent. more men are injured from falling and stumbling in the winter months than in the summer months. This is exclusive of street slipping accidents. The physical condition of the stairways and passageways is the same for both periods, the sole difference being in the illumination.

Poor Illumination in Storage Places

Many accidents occur in storage places due to inadequate illumination, but this fact is not often brought out in the reports. Raw material and finished product are often piled in uneven tiers, and these fall over at inopportune moments. Carelessness is very often the contributing cause, but in many cases a conscientious worker will pile material unevenly simply because the illumination is not sufficient to show him the tier is out of alignment.

Even the supposedly well-lighted working spaces in some shops are not immune from accidents. A certain work bench was well illuminated by local lights with proper reflectors, but the bench cast a shadow on the floor, while the general illumination was not sufficient to offset the shadow. There followed a sequence of accidents due to the toppling over of partly finished work piled in the shadow. With a higher intensity of general illumination accidents of this type were largely eliminated. Passageways that are traversed infrequently hardly justify the continual use of an illuminant, unless there is exposure to moving machinery or other hazards. Irrespective of the danger ele-

*Abstract from a paper presented at the 12th annual convention of the Illuminating Engineering Society, New York City, Oct. 10, 1918.

ment all passageways should have lighting units so installed that they can be turned on and off at either end.

A method is open to plant managers by which, at the same time, coal will be saved, better illumination provided and accident hazards reduced. It consists in the universal use of reflectors. Every plant manager (as part of his lighting policy) should adopt the principle of a proper reflector for every lamp. In the field of general illumination, the use of unshaded lamps, in connection with naturally dark walls and ceilings, or with white walls and ceilings that have become dirty, is not only wasteful and inefficient, but also increases the accident hazard from bright light sources. Proper reflectors would bring this wasted light under control, and at the same time reduce the accident hazard. In a limited number of cases smaller lamps could be substituted and still ample illumination would be provided; but for the most part reflectors should be used with the lamps now installed to bring about a much needed improvement.

In the field of local lighting there is much more room for saving and improvement. There are thousands of 120-watt carbon lamps, and many more thousands of 60-watt carbon lamps, used for local lighting about machines. It is the exception rather than the rule to find these lamps equipped with reflectors. Wire guards are more popular. For purposes of illumination a 15-watt or 25-watt tungsten-filament lamp with proper reflector would prove adequate. The question of serviceableness or of breakage of this lamp over the carbon lamp is dependent on local conditions. The recent agreement between lamp manufacturers and the Fuel Administration insures a reduction in the use of carbon lamps. In enforcing this policy lamp users should be warned against employing tungsten-filament lamps without reflectors. Exposure to the high intrinsic brilliancy of the tungsten filament involves a greater degree of vision impairment than with the carbon lamp. Wire guards will not serve, for although they protect the lamp from breakage to a certain extent, they afford no protection to the eye. The lamp can be replaced for twenty-five cents, but the eye—vision—infinitely more valuable, cannot be replaced at any price.

During a recent inspection a workman at a stamping press was noticed persistently standing at one side of his machine. In answer to inquiries the workman stated that he could not see unless he moved to the side and closer to the lamp; and he also stated that he was going to get a "big tungsten lamp." He was working on large tinned sheets, and while standing in front of his machine a dazzling reflection was directed toward his eyes. A simple adjustment of his local light changed the angle of incidence and reflected rays and thus removed the trouble.

This incident is more or less typical. There is so much unintelligent use of light in the form of unshaded or improperly placed lamps that we are fast approaching the state of being a nation of eyeglass wearers. An important remedial step will be taken when we whole-heartedly get behind the movement of "a proper reflector for every lamp."

Chicago Section A. S. M. E. Welcomes Secretary Rice

On Monday evening, Jan. 13, at the Engineers' Club, the Chicago Section of the American Society of Mechanical Engineers held a real get-together meeting. "Know each other better" was the slogan. Solo selections and "mob" singing helped to let down the bars and open the way to a sociable evening. Calvin W. Rice, the national secretary, was present to receive constructive suggestions on how to improve the society and incidentally to tell of the big things now under way or in contemplation that should render exceptional service to members and raise the profession to its proper plane of usefulness and responsibility in public affairs.

C. E. Lord, chairman of the Chicago Section, presided. His opening remarks showed that coöperation was the spirit of the day. The activities of the war had reacted on the country and made evident the necessity of coöperation. Engineers in particular were affected by the movement and the speaker referred to the efforts now being made by the four big national societies through committees on development and the Engineering Council to broaden the aims and the scope of the work being done.

At the annual meeting three subcommittees had been appointed: One to investigate the relations of the engineer to his work; the second, his relations with the community; and the third, the relations of the mechanical engineer to other engineers. These committees were coöperating, interchanging ideas and would have some definite suggestions to submit at the spring meeting. There was also a movement toward consolidation of engineering associations and suggestions made during the evening or later in writing would be given serious attention. The path should be blazed by coöperation among the local branches of the various engineering associations. In Chicago it was the hope to soon hold a joint meeting of the mechanical, electrical, mining and civil engineers.

In the discussion following it was pointed out that unsociability stood in the way of engineers getting anywhere. Technical training had stood between them and their opportunities. It should be an attribute instead of all. The engineer must be sociable, and it would seem that one of the primary duties of the local committee was to make engineers come to meetings and enjoy themselves.

As an introduction to telling what the society is doing and has in contemplation, Calvin W. Rice wanted the local section to think of him as a man familiar with the West from years of varied engineering experience in that section of the country. In his work in New York he was constantly thinking of the members in the West and trying to bring the society closer to them. One of the recent big things was the purchase of the *Engineering Index*. Eleven hundred papers would be reviewed and in addition to the index, abstracts of leading articles would continue. It was the object to make the *Journal* under the new name of *Mechanical Engineering* so readable and useful that no self-respecting engineer could be without it. Subscriptions were to be taken outside the society and the circulation increased so that the advertising rates could be raised to provide more money for the broadening work of the society. The boiler code had cost $12,000. There were plans for weekly publication of the *Journal*.

It had been a dream of the secretary to reduce the dues to $5 following the plan of the physicians, who had a membership of 86,000. To mount to the same plane as this profession, the engineers must undertake public service with no hope of reward. Statistics were given to show what the doctors and lawyers were doing to keep their professions clean. Engineers might well follow suit. They must take part in civic and national affairs, carrying out all forward movements of the day that belong to them. Money and time must be spent to render this service without becoming enmeshed in politics. Engineers should participate in matters of interest in the community. They should have papers on the subject, discuss it and, when a decision had been reached, see that the city employed the right men to do the work and paid the right price for it. In Washington the society was about to open an office to keep members posted on national affairs.

Efforts are being made to enhance the status of the sections, so that papers read there would have attention from the publication committee equal to that given papers for the spring or annual meetings. The employment bureau was well organized and active, costing about $10,000 per year. It had been coöperating to good advantage with the Department of Labor. There had been no extra charge to members and there was the free service of the library.

It had been the speaker's desire to see Chicago provided with a combined engineering building and club. It would require coöperation between all engineering societies in the city and the services of a competent secretary. The New York building was now clear of debt, and one of the possibilities was to mortgage it to provide a loan to put up the Chicago building.

Professor Green, chairman of the Research Committee, enumerated some of the things in which it was the wish all should take a part. Reference was made to the experimental work being done in the laboratories of the vari-

ous universities, technical schools and industrial concerns. Much of it was needless duplication and a waste of effort that might be eliminated if each knew what the others were doing. It was the plan to have a subcommittee in this section of the country that would be notified by the various members of the starting of some important work. The information would be passed on to the research committee, acting as a clearing house, and published in the *Journal*. In this way the profession would know what was being done and duplication could be avoided. When available, the results of the work also would be published. In addition it was the committee's desire to know what could be done in the Chicago district, so that it would make it possible to bring together the man who could do something and the concern that wanted something done. By clearing through the committee it would not be difficult to accomplish. Another advantage contemplated was the free preparation by the library of bibliographs on certain subjects requested by the members. Announcement would be made in the *Journal* that these bibliographs were being prepared so that others interested might obtain the benefit of the work.

B. A. Gayman, of the Link-Belt Co., was pleased to see the expansion under way. He was tired of the old cry of having something done for the local section instead of doing something for others.

Professor Gebhardt, of Armour Institute, had been impressed with the needless duplication of tests in the various engineering and industrial laboratories. Preliminary notices of tests would prevent this repetition. Armour for one would be glad to coöperate and give out for publication whatever useful information it might have.

What the Government is doing to place returning engineers was explained by Mr. Litchfield, a representative of the Department of Labor. A system of analysis and classification had been developed that would fit the man to the job, and the establishment of clearing zones would help to locate the engineers where their services were most needed. A clearing zone was already in operation in New York City and Mr. Litchfield was now organizing one in Chicago. The coöperation and assistance that had been given him by the various engineering societies had been highly appreciated.

Bituminous Coal Production by Months in 1918 and 1917

The estimates of bituminous coal production in the United States by months during 1918 and furnished to the United States Fuel Administration by the Geological Survey, including lignite and coal made into coke, compared with the corresponding months of 1917, show an increase of 34,092,437 net tons for the twelve months. The figures by months are as follows:

Months	1917 Net Tons	1918 Net Tons
January	47,967,354	42,607,206
February	41,352,711	44,384,937
March	47,868,652	48,631,115
April	41,854,320	46,590,570
May	47,086,452	50,927,195
June	46,824,646	51,758,214
July	46,291,572	55,587,312
August	47,372,226	55,732,092
September	45,107,956	51,757,334
October	48,337,726	52,885,513
November	47,689,801	44,386,987
December	44,037,147	40,634,525
Total	551,790,563	585,883,000

According to information collated by L. C. Harvey it appears that the quantities of pulverized coal used in the United States annually in various manufactures are as follows: In the cement industry, 6,000,000 tons; in the steel and iron industry, 2,000,000 tons; in the production of copper, 1,500,000 tons, and in the generation of power, 100,000 to 200,000 tons. To attain success the coal must be dried, crushed and pulverized until 95 per cent. will pass through a 100-mesh sieve, having 10,000 openings to the square inch. A cubic inch will contain over 200,000,000 particles, none of which will be greater than one-hundredth of an inch cube, and a large percentage less than one six-hundredth of an inch cube.

Rate of Coal Consumption in Electric Generating Stations

The Hydro-Electric Power Commission of Ontario, Canada, has published an interesting report on the rate of coal consumption in various electric generating stations and industrial establishments in the United States and Canada. The data were selected from such electric-power stations as use coal for fuel and which use it entirely for generating steam. All stations which use wood, oil, producer gas or any other fuel than coal, whether in part or not, and all stations acting as auxiliaries or stand-by plants in connection with power production by other means were disregarded.

As a result of numerous inquiries, replies were received from 73 stations, 50 per cent. of which were representative stations ranging in capacity from 150 kw. to 150,000 kw. The data, almost without exception, are from the averages of operation for the past five years. For convenience, the stations were divided into classes, according to size, as follows:

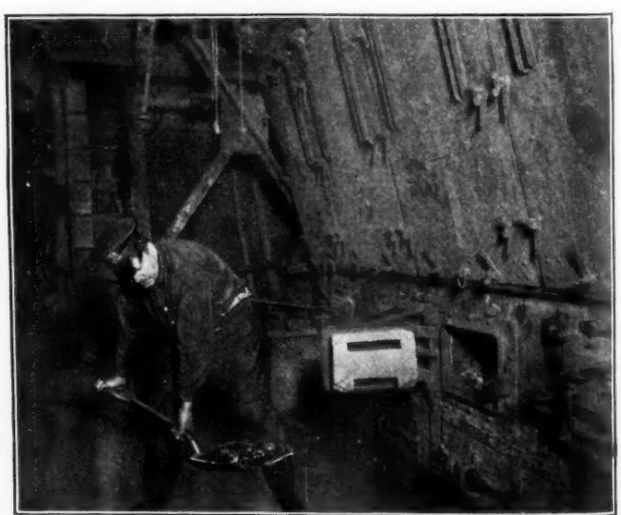
Class	Capacity in Kilowatts
A	Up to 1,000
B	1,001 to 5,000
C	5,001 to 10,000
D	10,001 to 50,000
E	50,001 to 100,000
F	Above 100,000

Among the interesting figures given in the report are found the following averages for the several classes of stations:

Class	Station Capacity Kw.	Station Capacity Hp.	Coal Consumption Pounds Per Kw.-Hr.	Coal Consumption Pounds Per Hp.-Hr.	Coal Consumption Tons Per Kw.-Yr.	Coal Consumption Tons Per Hp.-Yr.	B.t.u. Per Pound	Load Factor, Per Cent.	Efficiency, Per Cent.
A	650	870	7.65	5.70	34.60	25.10	12,500	29.3	3.5
B	2,980	4,000	4.30	3.20	19.00	14.00	12,900	34.2	6.2
C	7,230	9,700	4.07	3.04	17.80	13.30	11,900	31.7	7.0
D	24,600	33,000	2.91	2.17	12.75	9.52	13,600	36.0	6.6
E	96,000	128,800	2.01	1.50	8.80	6.57	14,000	36.9	12.1
F	149,000	199,500	1.92	1.45	8.40	6.26	13,500	44.7	13.1
Average	46,740	62,600	3.81	2.84	16.90	12.46	13,600	35.5	8.4

The efficiency in the foregoing table is the efficiency of conversion of the heat energy in the coal to the electric energy at the switchboard. The heat value of the coal is found by taking the heat value for each station, multiplying it by the average pounds of coal used per year by the station, adding the products for any one class and dividing the sum by the total weight of coal burned per year by the plants in that class.

A serviceable floor paint may be made by adding to one gallon of white-lead paint of the desired shade one-half pound of litharge which has been worked out smooth with a little of the paint. Mix only as wanted.



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DURING THE RECENT HARBOR STRIKE IN NEW YORK THE BOATS OF THE MUNICIPAL FERRY TO STATEN ISLAND WERE MANNED BY MEMBERS OF THE POLICE FORCE

Fires Caused by Chimney Sparks

By Chesla C. Sherlock

Sparks falling upon the property of others are frequently the direct cause of loss by fire, and it is naturally necessary to determine whether the owner or operator of the power plant is liable for the damage.

It is a fundamental proposition of the common law that the owner of a smoke-stack or chimney must exercise ordinary care in its erection, maintenance and operation in order to escape liability for any fires caused by sparks falling from it. The theory upon which the owner of the chimney is made a defendant is that he has been guilty of negligence in failing to exercise this ordinary care imposed upon him by the common law. Unless the party damaged can show affirmatively that there has been a breach of duty or negligence on the part of the owner of the smoke-stack, his cause for damages must necessarily fail.

The owner of a smoke-stack is not a guarantor to the community against fire that may arise from sparks falling from his chimney. But, says the law, he must do all that an ordinarily prudent person can, to prevent damage and loss to the property of others in the vicinity. He must build his chimney as well as he can; he must maintain it in the manner suggesting itself to ordinarily prudent men and he must use it in a manner consistent with these tests. Otherwise the owner has not exercised ordinary care in its maintenance. The overwhelming rule of authority is that the owner is not liable for a fire set by sparks from a chimney, unless the element of negligence is clearly established by proof. The liability, therefore, cannot be said to be absolute, and the great majority of these decisions have freed the chimney owner from any liability whatever, because negligence could not be proved, or it was shown, on the other hand, that he had exercised the care and caution of an ordinarily prudent man, with knowledge of the business and existing conditions.

Some Recent Decisions Rendered by the Courts of Different States

In a Maine case the owner of a mill constructed a smoke-stack upon approved plans such as were in successful use elsewhere among others engaged in the same business. He operated this chimney during a period of seventeen years and established the fact that during that time no known spark had fallen from the chimney until the one charged to have caused damage to the plaintiff's property fell from it. An expert was called who expressed the opinion that the stack was surrounded by highly inflammable material and that it should have been higher and should have been equipped with a spark arrester. The court held that the owner was not liable unless he was shown to have failed to perform his common law duty thereto.

A North Carolina case has been decided in which it was held that the burden of proving that ordinary care and caution had been exercised in the erection, maintenance and operation of a chimney was upon the owner and not upon the party damaged by sparks falling from it.

In a Kentucky case it was held that the question of negligence is one for the jury to determine from the evidence. It was shown that the wind was blowing directly from the chimney upon the plaintiff's property, that the spark arrester was not in place upon the chimney and that the owner thereof was burning highly inflammable wood. Said the court: "There is no doubt about the liability of a person for the consequence of a fire negligently started or controlled, and the question of negligence in this case is properly submitted to the jury."

In a Michigan case it was held that the owner of a smoke-stack might be found guilty of negligence rendering him liable for a fire caused by sparks where he had failed to install a spark arrester upon his chimney, even though it was shown that such appliances were not commonly in use in the community. A Virginia case, however, held that the mere fact that a spark arrester had not been used upon a smoke-stack did not, in itself, establish that the owner thereof was guility of negligence, where he had used due care and caution in other respects, and where it was shown that the use of such spark arresters was not customary among others in the same business in his community. In a South Carolina case it was held that the mere failure to use a spark arrester upon a smoke-stack was not, as a point of law, sufficient to charge the owner with negligence in operation.

In a Michigan case it was held that the owner of a saw-mill may be guilty of negligence for a failure to shut down his mill during a high wind and to keep it shut down during such high wind, in order to prevent damage and loss to others in the vicinity. This is an extraordinary feature of the owner's liability worthy of more than passing interest. A similar ruling was made in a North Carolina case, but it was further held that if such a showering of sparks takes place during a high wind, it must be remedied at once if the owner is to escape subsequent liability, and that if the defect is not remediable the mill must not be operated at all.

It has long been a rule of law that whoever maintains or uses an agency highly dangerous to the community must take adequate measures to control such agency before he even begins to use it. Fire is a highly dangerous agency, if steps are not taken to control it. When under control, it is not dangerous, but highly useful. Its usefulness ceases the instant it gets beyond control. Hence the reason for the utmost care and caution in the use of chimneys, especially in localities where they are likely to cause damage and loss by fire. The only measure of safety is for the owner to use every care and caution known to prudent men in the same business, or known to science or skilled experts. Defective chimneys are a constant menace, and the man who maintains such a chimney is living in constant danger of a verdict for damages in favor of another if fires are caused.

Italy the Worst Sufferer from Fuel Shortage

Italy, whose population as a whole was without coal for heating and in large part without gas for cooking, for many months of the war period, was the worst sufferer from fuel shortage among the allied nations, according to the report of the commission sent to Europe by United States Fuel Administrator H. A. Garfield.

Switzerland, which now faces a severe shortage, managed throughout the conflict to obtain a considerable supply of coal from Germany, although under an agreement forced on her "upon disadvantageous terms," the report says. France is continuing to furnish to Switzerland the tonnage Germany had allotted from Alsatian fields. Germany was Switzerland's chief source of supply before the war.

Belgium, the commission found, should be able to produce immediately more coal than needed for its own consumption since its industries were so thoroughly ruined during German occupation.

Representatives of the Italian government, the commission reports, urge an annual national supply of 12,000,000 tons to meet actual requirements. The whole of this quantity would of necessity be imported since Italy's only domestic fuel is a very poor grade of lignite. Under the spur of war needs, however, the production of this lignite was forced up to 2,500,000 tons in 1918, as against 700,000 tons before the war.

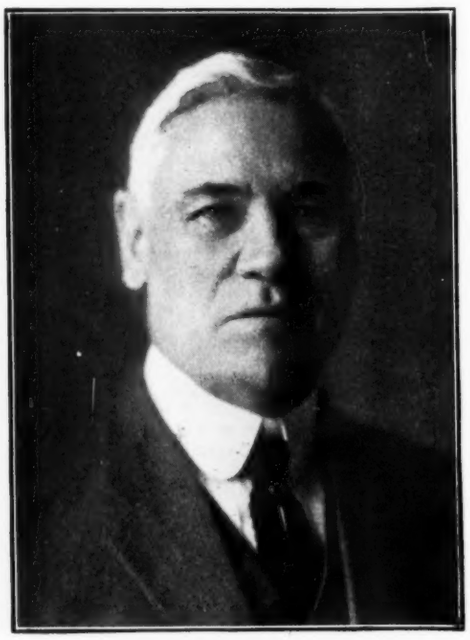
Italy was receiving but 7,000,000 tons of coal during the last years of the war, the report says, as against minimum necessities of 10,000,000. The report expresses some doubt as to whether Great Britain will be able, "in view of conditions at home and the heavy demand at home and elsewhere," to resume the annual exports of some 8,500,000 tons to Italy maintained in pre-war years.

Discussing exports from the United States to Italy, the report says that "due in part to war conditions and in part to a coal strike in Great Britain, they rose from 82,000 tons in 1913 to 287,000 in 1914, to 1,714,000 in 1915 and to 1,040,000 tons in 1916." These figures, the report states, are from Italian governmental sources, and are smaller than those of United States records.

Professor Rolla C. Carpenter

Rolla C. Carpenter, who until less than two years ago was professor of experimental engineering at Sibley College, Cornell University, died at his home in Ithaca, N. Y., on Jan. 19. Professor Carpenter was born in Orion, Mich., in 1852, received his early education in the schools and colleges of that state and graduated from the University of Michigan in 1875 as a civil engineer. After graduation he spent one year in railroad construction. Later, he became professor of mathematics and engineering in the Michigan Agricultural College, which position he held until 1890, when he went to Cornell to take the professorship in experimental engineering. He received the degree of C. E. from his alma mater; of M.S. in 1876; LL.D. in 1907 from the Michigan Agricultural College, and M.M.E. from Cornell in 1888.

While at the Michigan Agricultural College at Lansing, Professor Carpenter was consulting engineer for the Lansing Engine and Iron Works, at which time he designed the



PROF. ROLLA C. CARPENTER

governor for their automatic engine and also made a number of important tests to determine the friction of the various engines under different conditions. His consulting practice in other directions was also very large, as he was engineer for a number of important constructions and installations in the State of Michigan. Largely as a result of his work at Sibley College, Cornell has today one of the best organized and equipped experimental laboratories in the country, and in experimental work he has long been a recognized authority. In addition to his college work he continued to increase his extensive consulting practice in mechanical, electrical, heating and hydraulic engineering. He directed the installation of the high-pressure fire system of Baltimore in 1911 and installed a high-pressure pumping system in New York in 1912.

He was also a noted inventor and author. His inventions include among others a steam separator, a steam calorimeter and a fuel calorimeter. His books include the well-known textbooks, "Experimental Engineering," "Heating and Ventilating Buildings," and "Internal Combustion Engines." Besides these he has written many important articles for the American Society of Mechanical Engineers and for various engineering periodicals. He retired from Sibley College early in 1917 after nearly thirty years of teaching. He was a judge in the Department of Machinery at the Chicago Exposition in 1893, the Buffalo Exposition in 1901 and the Jamestown Exposition in 1907.

Professor Carpenter was a member of the following engineering societies and clubs: American Society of Mechanical Engineers, of which he was a past vice president; American Society of Heating and Ventilating Engineers, of which he was a past president; American Institute of Mining Engineers; American Society of Refrigerating Engineers; American Society for Testing Materials; American Society of Automotive Engineers; Michigan Engineering Society; the Engineers' Club and the New York Railroad Club.

The late Doctor Thurston said of Professor Carpenter's work as a teacher: "He has met with marked success, and his method of going directly to the pith of his subject has made him a famous lecturer with his students." He is survived by his widow and three children.

Pasadena's Light Plant Pays

The users of electric light in Pasadena, Calif., says the Kansas City *Star*, have saved on the average of $134,000 a year for the last eleven years by owning their own electric-light plant. The saving is calculated on the basis of the rates charged by privately owned plants in neighboring cities.

The report for the year, just issued, contains interesting information. Costs, of course, have been mounting steadily. The plant, for instance, uses oil fuel, and its cost has gone up 55 per cent. over the price of the year preceding. While the gross revenues are up 3 per cent., the net receipts are 14 per cent. below those of the previous year. Yet with allowance made for depreciation, for interest, and for taxes, the net earnings would be 6½ per cent. This showing was made with an average rate to consumers of a little less than 5 cents a kilowatt hour.

Pasadena, like Kansas City, Kan., finds the ownership and operation of an electric-light plant a highly profitable undertaking—although every privately owned corporation in the country can demonstrate that municipal ownership can never, never pay.

Permits Required for Certain Smokeless Coal Shipments

To correct a slight misconception of its order of Jan. 16, regarding the removal of restrictions on shipments of bituminous coal and smokeless coal by way of the docks on Lake Michigan and Lake Superior, the United States Fuel Administration points that this order still keeps in effect a provision that:

Low-volatile smokeless coal shall not be sold or shipped from docks on Lake Michigan and Lake Superior for use by domestic consumers unless a permit for such sale or shipment shall first have been obtained from the district representative of the United States Fuel Administration in charge of said docks.

The order also declared valid all permits heretofore or hereafter obtained from the district representative in charge of said docks, under the proviso of the order of Jan. 2, 1919, although granted without the approval of the Federal Fuel Administrator.

The Keynote of Successful Management

Charles Schwab says that he has put into practice for thirty-five or forty years of industrial pursuits, one particular thing, which he believes is the keynote of everything he strives to do. That particular thing is encouragement and not criticism in dealing with all his men.

I have yet to see the man, however great and exalted his situation, who is not susceptible to the approval of his fellow-men. I have yet failed to see the man who is worth calling a man, who does not put forth his best efforts under the approval of his fellow-men. And the severest criticism that can come to any man is not to be noticed at all. When a man is not noticed, he knows that he has not gained the approval of his fellows, but when he is approved he gives his best effort.

In nearly all cases the question of time enters in when renewing boiler tubes in order to get the unit in service as soon as possible. It is necessary in consequence to make careful plans to determine how the tube is to be removed from the boiler after being cut out and how it is to be replaced. The plan followed depends on local conditions, as the type of stoker and the position of boiler in the boiler room bring about varying situations. In each case the job should be sized up from every angle, and material and men provided so that no unnecessary delay will occur in the preliminary work or in the actual work of renewal. This includes getting together blocks and tackle, ladders, the instruction of the men, the removal of obstructing brick, opening of coal-bunker doors, etc. The new tubes should be assembled and cleaned, and the ends first to go into the firebox noted, as well as the number of the tube, which indicates the row in which it is to be placed.

New Publications

HYDRAULIC EXPERIMENTS WITH VALVES, ORIFICES, HOSE, NOZZLES AND ORIFICE BUCKETS. By Arthur N. Talbot, Fred B. Seeley, Virgil R. Fleming and Melvin L. Enger. Published by the University of Illinois, Urbana, Ill. Paper, 6 x 9 in.; 76 pages; 28 illustrations. Price, 35 cents.

This bulletin, which is No. 105 of the series published by the Engineering Experiment Station of the University of Illinois, contains the results of four separate sets of experiments that were made in the investigation of certain problems and that were not judged extensive enough to warrant publication as separate bulletins. The investigations are largely the outgrowth of experimental work begun by students in the preparation of theses and extend over a number of years. The experiments are not exhaustive in their scope, but it is believed that the data obtained are of sufficient value to warrant publication. The four papers in the bulletin are entitled: "Loss of Hydraulic Head in Small Valves"; "Flow of Water Through Submerged Orifices"; "Fire Streams from Small Hose and Nozzles"; and "The Orifice Bucket for Measuring Water."

Personals

William McElraevy has been appointed district manager of the Dominion Asbestos and Rubber Corp. of New York. Mr. McElraevy was formerly manager of the New York branch of the power plant specialty department of the H. W. Johns-Manville Co., in which capacity he served for nine years.

Engineering Affairs

The American Society of Heating and Ventilating Engineers will hold its annual meeting at the Engineering Societies Building, 29 West 39th St., New York, Jan. 28-30. The program promises to be an interesting one and a very successful meeting is anticipated.

The Ohio Engineering Society on the first day of its annual convention in Columbus, voted unanimously in favor of the principle of licensing engineers. It is expected that a bill will be presented to the state legislature at its present session. The action of the Ohio Engineering Society followed an address on "Licensing," by C. E. Drayer, secretary of the American Association of Engineers.

The American Association of Engineers—The Compensation Committee of the Chicago Chapter, will report at the regular meeting Friday, Feb. 7. A paper will be presented by J. H. Prior formerly chief engineer, Illinois State Public Utilities Commission, followed by a discussion prepared by Langdon Pearse, engineer, Sanitary District of Chicago. The committee is considering tables of minimum salaries for engineers, which have been placed before the Chapter.

Miscellaneous News

A Boiler Exploded in the steam-heating plant of the Denver (Colo.) Gas and Electric Light Co. on Jan. 14, killing one of the firemen and injuring two others. All the piping in the rear of the boiler was blown out. The cause of the explosion is unknown.

Zone Regulations on Coke and all coal except Pennsylvania anthracite will be suspended Feb. 1, it has been announced by the Fuel Administration. Likewise all price regulations, including agents' commissions and wholesale and retail margins on coke and all coal, except Pennsylvania anthracite, will be suspended. These regulations, it was announced, are subject to reinstatement, if price, wage, labor, production or other conditions arise that require it.

Business Items

C. S. Hallowell, Inc., has opened offices at 103 Park Ave., New York City, for the conduct of a general advertising agency.

Busch-Sulzer Bros.-Diesel Engine Co., who have been engaged in building marine engines for government work during the war, announce that they have again resumed commercial business.

Plant Analysis Service of the Goodyear Rubber Co.—Plant analysis in reference to the belt drives of a given plant is a comparatively new department of the Goodyear Tire and Rubber Co. Its function is to examine a plant and make recommendations as to the proper belting, strength, size and other conditions to cover the particular needs involved. The service of the staff of experts is available on application to the company.

The Wheeler Condenser and Engineering Co., of Carteret, N. J., has obtained from the Schütte & Koerting Co., of Philadelphia, through the Alien Property Custodian the exclusive right to manufacture and sell steam-jet air pumps under patent No. 968,926 in connection with surface condensers, jet condensers, barometric condensers, vacuum pans and evaporating apparatus. This patent covers the feature of two or more steam jets working in series with a condenser between the jets.

Trade Catalogs

The Prevention of Rusting or Corrosion of Iron and Steel. Dearborn Chemical Co., Chicago, Ill. An attractive 24-page booklet fully describing the company's list of specialties which are at present being put on the market. A copy may be had upon application to the company's Department of Specialties.

The Jeffrey Manufacturing Co., of Columbus, Ohio, has just issued its catalog No. 244, which contains 40 pages, illustrated and devoted to details of elevators selected out of numerous styles used in the handling of a wide range of materials in various industries throughout the country. The numerous examples and subjects outlined in this book enable the prospective purchaser to readily select the proper standard elevator to meet his requirements, thus saving time and expense required in making layouts and drawings for his own particular needs.

New Construction

PROPOSED WORK

Mass., Danvers—The town has petitioned the Legislature for authority to borrow $20,000 to rebuild and relay its water-mains and improve the storage pumping and distribution facilities.

Conn., Danbury—The Connecticut Power & Lighting Co. plans to build additions to its plant.

N. Y., Brooklyn—The Brooklyn Synagague, 1093 Sterling Pl., will install a steam heating system in its proposed 2 story, 80 x 100 ft. synagague. Total estimated cost, $100,000. M. Raisin, Rabbi.

N. Y., Brooklyn—R. T. Short, Arch., 370 Macon St., will receive bids until Feb. 1, for the erection of a 2 story, 80 x 180 ft. theater on Flatbush and Rogers Ave., for the Jewel Building Co., 170 Broadway, New York City. A steam heating system will be installed in same. Total estimated cost, $250,000.

N. Y., New York—Gronenberg & Leuchtag, Arch., 303 5th Ave., will receive bids until Apr. 2, for the erection of a 10 story, 100 x 100 ft. hotel on 43rd St. near 8th Ave. for Henry Claman, 243 West 43rd St. A steam heating system will be installed in same. Total estimated cost, $200,000.

N. Y., New York—A. C. Merkle, Inc., 233 Broadway, will install a steam heating system in the 4 story factory, which will be built on West and Horatio St. Total estimated cost, $145,000. A. L. Lucius, 38 Park Row, Arch.

N. Y., Sonyea—P. L. Lang, Pres. Bd. of Mgrs., Craig Colony for Epileptics, 7 Wall St., New York City, received bids for installing a heating system in the new kitchen building, from E. Towe, 32 Oak St., Rochester, $7200; Austin Heating Co., 121 West 42nd St., New York City, $8875; Murtaugh & Reddington, 26 Pleasant St., Rochester, $8987.

N. Y., S. I., Stapleton—J. A. Wetmore, Superv. Arch., Treas. Dept., Washington, D. C., will receive bids until Feb. 10, for the installation of a heating boiler, hot water tank, etc., for the hospital unit, type A, at the U. S. Marine Hospital here.

N. Y., Utica—The State Hospital Commission, Capitol, Albany, will receive bids until Feb. 11, for the installation of boilers, piping, etc., at the Utica State Hospital, here. Estimated cost, $75,000. Noted Jan. 14.

N. Y., Watertown—City has had plans prepared by T. L. Tomlines, Eng., City Bank Bldg., Syracuse, for the development of power at the Diamond Island site on the Black River. Plans will include the erection of concrete dam, power house and tail race. Total estimated cost, $600,000 of which about $170,000 has already been appropriated.

N. J., Linden—The Board of Education received only bid for installing a heating system in the proposed addition to P. S. No. 2, from J. H. Cooney & Co., 210 North 4th St., Harrison, $6500.

N. J., Newark—E. and H. Levy plan to build a power house on Purdy St.

Penn., Springdale—The Penn Power Co., Benedum Trees Bldg., Pittsburgh, is building 1 story, 200 x 900 ft. power plant in connection with a mine development here. Total estimated cost, $5,000,000. Sanderson & Porter, 52 William St., New York City, Engr.

Md., Princess Anne—Town plans to build a water distribution system. Plans include the erection of 1 or more wood stave tanks, installation of a gasoline pump, etc. Estimated cost, $60,000. C. Lanksford, Pres. L. J. Houston, Fredericksburg, Engr.

Ga., Cordele—City plans to build an electric lighting plant. Address the Mayor.

Miss., Iverness—City will receive bids in March for improvements to its electric lighting plant and water-works system. Plans include installing oil engines, pumps, alternators, miscellaneous line material, etc. Former bids were rejected. X. A. Kramer, Magnolia, Engr. Noted Dec. 31.

Penn., Morristown—The Southern Ry., 1300 Pennsylvania Ave., Washington, D. C., plans to build a pumping station near here. W. H. Wells, Washington, D. C., Ch. Eng.

Ohio, Cleveland—W. R. Powell, Arch., 705 Rose Bldg., will receive bids until Mar. 15, for the erection of a 2 and 6 story, 78 x 381 ft. market house at 11826 Detroit Ave., for the Lakewood Market House Co. A steam heating system and refrigeration plant will be installed in same. Total estimated cost, $200,000.

Ohio, Norwood—The Board of Education will receive bids until Feb. 24, for the erection of a 2 story, 80 x 139 ft. school on Allison St. A hot air heating system may be installed. Total estimated cost, $150,000. H. Hake, Telephone Bldg., Cincinnati, Arch.

Ohio, Oberlin—The Board of Education will install a steam heating and ventilating system in the proposed 2 story, 75 x 180 ft. high school which it plans to build. Total estimated cost, $225,000. E. F. A. Root, Pres. F. C. Warner, 767 Hippodrome Bldg., Cleveland, Arch.

Ind., Rockport—Commissioners of Spencer Co. will receive bids until Mar. 3, for the erection of a 2 story, 105 x 112 ft. courthouse. A vacuum and C. I. radiation system and low pressure boilers will be installed in same. Total estimated cost, $175,000. Snider & Rotz, 703 Merchants Bank Bldg., Indianapolis, Heating Eng.

Mich., Bay City—City plans to build an addition to its electric light and power plant. New equipment will also be installed. Estimated cost, $125,000. C. L. De Bates, Supt.

Mich., Detroit—The Morgan & Wright Tire Co., foot Bellevue St., will install a steam heating system in the proposed 7 story, 140 x 215 ft. warehouse which it plans to build. Total estimated cost, $750,000. Lockwood Greene & Co., 38 South Dearborn St., Chicago, Ill., Eng.

Mich., Kinds—Village voted to issue $10,000 bonds to purchase and install electric lighting equipment.

Ill., Lewistown—The Thompson Drainage & Levee Dist., Fulton Co., will receive bids until Feb. 3, for the erection of a pump station equipped with 3 low lift, double suction centrifugal pumps with intake and discharge pipes, 3 electric motors, 1 motor exhauster, switchboards, meters, electric lighting, etc., in connection with the irrigation project here. Goodell & Millard, Beardstown, Eng.

Wis., Sheboygan—The Badger State Tanning Co., South Water St., will receive bids in February for the erection of a 2 story, 68 x 114 ft. addition to its power house. Juul & Smith, Imig Bldg., Arch.

Kan., Hiawatha—City is having plans prepared by Black & Veatch, Eng., Interstate Bldg., Kansas City, Mo., for the construction of a water supply pump house, transmission line, etc.

Neb., Lincoln—City is having plans prepared by A. Dobson, City Eng., for the erection of an addition to the power house. New equipment will be installed in same.

Mont., Cascade—City will receive bids until Feb. 3, for the erection of a 14 x 14 ft. pump house and will install a 10 hp. motor direct connected to a triplex pump 100 gal. per minute.

Ark., Benton—G. A. Smith, Supt. of Water Plant, has acquired an electric plant and will install an engine and a 125 kw. generator in same.

Okla., Duncan—City will award the contract for the erection and equipment of an electric lighting plant and a water-works system. Benham Eng. Co., Colcord Bldg., Oklahoma, Consultg. Engr.

Colo., Holyoke—The town will soon award the contract for the construction of a pumping plant and the installation of two 125 k.v.a. alternators, one 10,000 gal. fuel oil tank, etc. R. D. Salisbury, 1415 East Colfax Ave., Denver, Eng.

N. M., Mountainair—R. Adams and C. H. Eichelberger have applied for a franchise to build and operate electric-light and water works systems here.

Utah, Castlegate—The Utah Fuel Co. is having plans prepared for the erection of a water purification plant. Project includes a rapid sand filter, storage tanks, pumping plant, etc. Estimated cost, $40,000.

Wash., Valley—The Admiral Mining Co. is building a water power plant to have a capacity of 130 h.p., a compressor plant with 8 drill capacity and a concentration mill with 250 ton daily capacity. Extensive additional underground development is also contemplated. About $75,000 will be expended on project. J. R. Brown, 402 Rookery Bldg., Spokane, Mgr.

Calif., El Centro—The Southern Sierra Power Co., Riverside, plans to build a 30 mi. high tension transmission line from here to Calexico. Estimated cost, $35,000. A. B. West, Riverside, Gen. Mgr.

Calif., Los Angeles—The Southern California Edison Co., 301 South Broadway, plans to expend about $20,000,000 to develop 150,000 additional horsepower in the hydro-electrical plants and building transmission and distributing lines throughout southern California. W. Dennis, Ch. Engr.

Ont., Amherstburg—Brunner-Mond Co. of Canada, Ltd., plans to build a transmission system along certain highways in Anderdon Township. A. C. Maillou, Clk.

Ont., Ancaster—City will vote on a by-law for the installation and supply of hydro-electric power. Estimated cost, $17,000.

Ont., Toronto—City plans to extend its hydro electric line. About $650,000 will be expended.

Que., Sherbrooke—City will issue $90,000 debentures for the construction of electric distributing stations.

CONTRACTS AWARDED

N. Y., New York—M. Groh's Sons, 238 West 28th St., has awarded the contract for the erection of a 10-story, cold-storage warehouse, to Potterson Bros., 215 West 28th St. Estimated cost, $250,000. Noted Dec. 31.

N. Y., Niagara Falls—The Niagara Falls Power Co., Canal Basin, has awarded the contract for the erection of a 3-story, 99 x 158 ft., power substation, to the Snyder-Gillette Contg. Co., Gillette Court. Estimated cost, $35,000.

N. Y., Rockaway—The Bureau of Yards & Docks, Navy Department, Washington, D. C., received bids Jan. 20 for installing a heating system in hangars C, D and E. (work complete), from the Austin Heating Corporation, 121 West 42nd St., New York City, $25,745; American Foundry & Furnace Co., 1008 Mutual Bldg., Richmond, Va., $25,815 (90 days); Gillis & Gehagen, 537 West Broadway, New York City, $25,936 (60 days). Noted Jan. 14.

N. J., Jersey City—The Ewald Box Manufacturing Co. has awarded the contract for changing its factory from a steam into an electric plant, to W. Coleman, 11 Willow Court. Estimated cost, $3000.

Penn., Philadelphia—City received only bid for the erection of a power plant, fire and police station at 24th and Rittner Sts., from F. H. Stewart Electric Co., 37 North 7th St., $304,245. Noted Dec. 31.

Penn., Pittsburgh—The Carbon Steel Co., 32nd St. and Allegheny River, has awarded the contract for the erection of a 1-story, 40 x 168 ft. boiler house, to W. N. Kratzer & Co., 3212 Smallman St.

Va., Norfolk—The Norfolk & Hampton Road Dry Dock & Ship Repairing Co., Bank of Commerce Bldg., has awarded the contract for the erection of a shipbuilding plant consisting of various 1-story buildings, to J. Stewart & Co., 30 Church St., New York City. A steam heating system will be installed in same. Total estimated cost, $7,000,000.

Ohio, Columbus—The U. S. Government, Washington, D. C., has awarded the contract for the erection of 145 one story additions to the storehouse here, to the Hunkin-Conkey Co., 601 Century Bldg., Cleveland. A steam heating system will be installed in same. Total estimated cost, $1,500,000.

Iowa, Sioux City—The Mariner Terminal Elevator Co., Grain Exchange, has awarded the contract for the erection of a terminal elevator on 5th and Pavonia St., to the Younglove Constr. Co., 412 United Bank Bldg. Estimated cost, $150,000. Eighteen 500 h.p. electric motors, dryer, boiler and radiation system will be installed in same.

Kan., Garnett—City has awarded the contract for the erection of a pump house and pit on Cedar Creek near here, to A. H. Stimson, Topeka. Estimated cost, $5110.

N. S., Sydney—The Dominion Iron & Steel Co. has awarded the contract for the erection of a power station capable of developing 11,500 kw. to the Foundation Co., Ltd., 224 St. James St., Montreal, Que.; cost plus percentage.

Ore., Portland—The Dock Commissioners received bids Dec. 30, for the installation of electric appliances at Pier No. 1 of St. John's Terminal, from the National Electric Co., Railway Exchange Bldg., $17,422; Jaggar Sroufe Co., 103 West Park, $20,190; NePage-McKenny Co., 388 Burnside St., $20,612.

THE COAL MARKET

BOSTON—Current quotations per gross ton f.o.b. mines are as follows:

ANTHRACITE

	Circular Current		Circular Current
Buckwheat	$3.40	Boiler	$2.65
Rice	2.90	Barley	2.40

All rail to Boston is $2.86.

BITUMINOUS

Bituminous, $8 to $8.75.

Pocahontas and New River, f.o.b. Boston, $8.35 to $8.90.

NEW YORK—Current quotations per gross ton f.o.b. Tidewater at the lower ports* are as follows:

	Circular	Individual		Circular	Individual
Pea	$6.55	$7.30	Broken	$7.80	$8.55
Buck.	5.10	5.90	Egg	7.70	8.45
Rice	4.65	5.10	Stove	7.95	8.70
Barley	4.15	4.30	Chestnut.	8.05	8.80

BITUMINOUS

Current quotations, gross tons, based on Government prices at the mines, net ton; f.o.b. Tidewater, at the lower ports, are as follows:

	Mine Gross	F.O.B. N.Y. Gross
Central Pennsylvania (Mine run, Prepared or Slack)	$3.30	$5.45
Upper Potomac, Cumberland & Piedmont Fields:		
Run of Mine	3.08	5.23
Prepared	3.36	5.51
Slack	2.80	4.95

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The rate to the upper ports is 5c. higher than to the lower ports

PHILADELPHIA—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Current	One Yr. Ago	Current	One Yr. Ago
Pea	$4.80	$3.40	$6.05	$4.30
Barley	2.40	1.90	3.30	2.15
Buckwheat	3.40	2.90	4.45	3.50
Rice	2.90	2.40	3.80	3.40
Boiler	2.70	2.20	3.70	3.30

CHICAGO—Steam coal prices f.o.b. mines:

Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.55—2.70	$3.25—3.40
Mine-run	2.35—2.50	3.00—3.15
Screenings	2.05—2.30	2.75—2.90

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared Sizes	Slack or Screenings
Big Seam, Mary Lee, New Castle, Blue Creek, Brookdale, Milldale, Henry Ellen or Acmar	$2.45	$2.75	$2.40
Cahaba, Black Creek, Milldale, Carter and Durie seams, and Underwood seam in Etowah and Blount Counties, Jefferson seam in Marion, Walker and Winston Counties	3.45	3.75	3.10
Pratt, Brookwood, Nickel Plate, America, Jagger, Coal City, Jefferson (except in Walker, Marion and Winston Counties), Mt. Carmel seam or upper branch of Big Seam on Birmingham Mineral south of Bessemer	2.85	3.05	2.45
Helena and Harkness seams and coal mined by No. 2 Belle Helen, and Youngblood seam	2.90	3.20	2.70
Climax seam near Maylene.			

ST. LOUIS—Prices per net ton bituminous coal f.o.b. mine today as compared with a year ago are as follows:

	Williamson and Franklin Counties, Mt. Olive and Staunton	Standard
Prepared sizes (lump, egg, nut, etc.)	$2.55@2.75	$2.40@2.70
Mine-run	2.35@2.50	2.20@2.30
Screenings	2.17@2.32	1.50@1.50

Williamson-Franklin rate to St. Louis is $1.10.
other rates p. 95.